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ABSTRACT

Presented is material from an information program designed to help citizen advisory groups and local officials improve decision-making in water quality planning. The program is designed to help people focus on essential issues and questions by providing materials suitable for people with non-technical backgrounds. Chapter topics include: (1) Multiple Use; (2) Industrial Pretreatment; (3) Wastewater Facilities Operations and Management; (4) Urban Stormwater Runoff; (5) Nonpoint Source Pollution - Agriculture, Forestry, and Mining; and (6) Groundwater Contamination. The volume includes reading materials and selected references. (RH)

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An Information Program
for Advisory Groups

Working for Clean Water

3

Citizen Handbooks

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Preface

This information program is based on the assumption that the reader already has a basic knowledge and awareness of the important life-sustaining role that water plays in the biological, chemical, and physical cycles on the planet Earth. If the reader desires this kind of information, your local reference librarian can recommend books that discuss the topic.

* * * * * * * * * * * * *

Working for Clean Water is an information program designed to help citizen advisory groups and local officials improve decision-making in water quality planning. The idea is simple—the more people know about a subject, the better prepared they are to make workable and practical decisions in meeting community needs. This program is aimed at helping people focus on essential issues and questions by providing materials suitable for persons with nontechnical backgrounds. Although this material was conceived and developed with the advisory group member in mind, it is useful for many other training situations. Persons benefiting from these water quality management educational materials will be local, state, and federal employees, public school and college students, and wastewater treatment authority members. The materials have already been used for these groups and were found to provide an excellent introduction to the subject.

These materials include handbooks, audiovisual presentations (slide/tape or 16 mm film), and instructor guides. The audiovisual presentations highlight major issues and important aspects of each topic. The handbooks elaborate on these points, provide additional detailed information, and include examples of how other communities have dealt with water quality and wastewater treatment issues. The instructor guides give suggestions on how to hold an information session including guided discussions on local topics of concern and some problem-solving exercises.

This volume is one of a series of three which contain the citizen handbook materials. The eighteen topics discussed in the individual handbooks are chapters in this three-volume set. The chapter topics are:

- Role of Advisory Groups
- Public Participation
- Facility Planning in the Construction Grants Program
- Municipal Wastewater Processes: Overview
- Municipal Wastewater Processes: Details
- Small Systems
- Innovative and Alternative Technologies
- Water Conservation and Reuse
- Land Treatment
- Cost-Effectiveness Analysis
- Environmental Assessment
- Financial Management
- Multiple Use
- Industrial Pretreatment
- Wastewater Facilities Operation and Management
- Urban Stormwater Runoff
- Nonpoint Source Pollution: Agriculture, Forestry and Mining
- Groundwater Contamination

The material in each chapter is not designed to make technical experts out of the readers. However, the chapters do contain essential facts, questions to consider, advice on how to deal with issues, and clearly-written technical background material. In short, each chapter provides information that will help advisory group members and local officials to better fulfill their roles.

Each chapter contains material addressed specifically to advisory group members; this information is printed in boldface type. There are often boxed-in sections of material containing examples, lists of advantages and disadvantages, questions addressed to local community needs, and other useful information. Two sections of material common to all chapters are case studies which are found on pages tinted gray and a "Need More Information?" section containing annotated resource materials with information on how to obtain them. In addition, a glossary of terms is provided at the end of each volume.

If you would like more information about the program, copies of handbooks, instructor materials, or audiovisual aids, contact the EPA Information Dissemination Project for price lists and rental information:

EPA Information Dissemination Project
1200 Chambers Road, Room 310
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Glossary

a

Absorption Field (Bed)—type of absorption system which uses a wide trench partially filled with gravel or crushed stone and covered with soil. Piping distributes treated sewage evenly throughout the bed for seepage into the ground.

Account Sheet—a table for displaying impact assessment data to facilitate the comparison of alternatives.

Acid Mine Drainage—water with an acidic pH which drains from working or abandoned mines.

Activated Sludge—waste solids that have been aerated and subjected to bacterial action; process for removing organic matter in raw sewage during secondary waste treatment.

Adsorption—attraction and accumulation of one substance on the surface of another.

Ad Valorem Tax—a tax imposed at a percent of the assessed property value.

Advanced Waste Treatment—treatment processes that can increase waste removal beyond the secondary or biological stage; it includes removal of nutrients such as phosphorous and nitrogen and most suspended solids.

Aeration—circulation of oxygen through a substance; aids in purification.

Aeration Tank—tank in which oxygen is circulated through wastewater as an aid in purification.

Aerobic Digestion—breakdown of organic material by bacteria in the presence of oxygen.

Aerobic Treatment—treatment of wastewater using organisms which are dependent on the presence of oxygen to break down organic matter.

Aeroclarifier—settling tank utilizing the circulation of oxygen through the wastewater to aid in purification and sedimentation.

Alkaline—wastewater with a pH above 7.0; contains relatively few hydrogen ions as compared to an acid.

Alternative Wastewater Treatment Systems—various non-conventional methods of central or community wastewater treatment, sludge treatment, energy recovery, and onsite systems that can save energy or cost as compared to conventional treatment systems; they are eligible for an additional 10 percent federal funding over conventional systems.

Ammonia Stripping—process in which gaseous ammonia is removed from water by agitating a water-gas mixture in the presence of air.

Amortize—payment of loans with interest over a period of time.

Anaerobic Digestion—breakdown of organic material by bacteria in the absence of oxygen.

Aquaculture—growth of plants and animals in water instead of soil.

Aquifer—underground bed or layer of earth, gravel, or porous stone that serves as a reservoir for groundwater.

Aquifer Recharge—adding water to an aquifer either by spreading on the ground surface or direct injection through wells.

Artesian—water confined under pressure between impermeable layers such as clay or shale.

b

Best Management Practice (BMP)—technique which deals most effectively with a given problem.

Biochemical Oxygen Demand (BOD)—amount of dissolved oxygen required by bacteria to decompose organic matter in water; measure used to indicate the amount of organic wastes in water.

Biodegradable—capable of being decomposed through the action of microorganisms.

Biodisc—a large rotating plastic disc which provides a surface area for the attachment and growth of microorganisms.

Biological Contactor—a series of closely-spaced biodiscs that provide a large surface area for the biological removal of organic pollutants from wastewater.

Boundary—geographical area or the degree of study.

Buffer Strip (Zone)—area of land which acts as a health and safety barrier between a treatment site and the public.

c

Carcinogen—cancer-causing substance.

Catch Basin—basin located at the point where a street gutter discharges into a sewer; catches and retains matter that would not pass readily through the sewer.

Categorical Standards—effluent standards established for a particular industrial category.

Centrifugation—the separation of sludge particles from the liquid by a rapidly rotating drum.

Chemical Oxygen Demand—measure of the equivalent amount of oxygen required to break down organic and inorganic compounds in water.

Chemical Precipitation—treatment technique that utilizes chemicals, known as coagulants, to cause solids in the wastewater to clump together and settle.

Chlorine Contact Chamber—tank in which chlorine is added to treated wastewater for the purpose of disinfection.

Clarifier—settling tank where solids are removed from wastewater.

Cluster System—community form of onsite disposal, in which effluent from several individual septic tanks is transported to a central location for disposal.

Coagulation—addition of chemicals such as lime or alum to clump together solids in wastewater so that they settle out faster.

Coliform Bacteria—bacteria found in the intestinal tracts of humans and other animals; indicator of fecal pollution.

Collection Line or Collector Sewer—sewers including laterals, submains, and mains.

Combined Sewer—drainage system that carries both sewage and stormwater runoff.

Comminutor—device that catches and shreds large objects in the raw wastewater entering a sewage treatment plant.

Composting—natural biological breakdown of organic material in the presence of air; a humus-like material is the end product.

Computer Modeling—the programming of a computer to use related input data for analyses or problem solving; such programs can predict events such as stormwater runoff and pollution loading.

Conditioning—treatment of sludge with chemicals or heat so that the water may be readily separated.

Connection Charge—the one time fee charged to property owners for the privilege of connecting to a central sewer system.

Consultation—an exchange of views between governmental agencies and interested or affected persons or organizations; involves communication techniques such as advisory groups and public hearings.

Contamination—presence of undesirable substances of biological, inorganic, or organic composition.

Cost-Effectiveness Analysis—determination of whether a project or technique is worth funding; both monetary and nonmonetary factors are involved.

Criteria—guidelines for making decisions.

d

Decreasing Block Rate Structure—cost of water to consumer increases as consumption increases, but at a decreasing rate.

Deep-Well Injection—pumping high quality treated wastewater into the groundwater table.

Delphi Survey—panel of experts independently moving towards consensus through responses to rounds of questions.

Demography—statistical study of populations.

Denitrification—anaerobic biological conversion of nitrates into nitrogen gas.

Depreciation Costs—those costs associated with the loss of value for capital investments over a period of time due primarily to aging.

Detention Basin—small basin for collecting stormwater runoff until the particulates picked up by rain water have settled.

Dewatering—separation of water from sludge by vacuum, pressure, or drying processes.

Digester—closed tank where wastewater sludge is broken down by intense bacterial action.

Direct Discharge—discharge of an industrial waste other than to a publicly-owned treatment works.

Disinfectant—chemical such as chlorine that is added to the wastewater to kill bacteria.

Dissolved Solids—total amount of extremely small organic and inorganic material contained in water; material capable of passing through a filter paper.

Dosing Tank—receptacle in septic systems for providing large flow rates for a short time, rather than a trickle all the time. A dosing tank fills to a certain level and then flushes by siphon action.

e

Easement—a right of way granting the use of land for a certain period of time.

Ecology—study of relationships between organisms and their surroundings.

Ecosystem—the interaction of organisms with their environment.

Effluent—treated or untreated wastewater discharged into the environment.

Electrodialysis—process by which electricity and a membrane separate mineral salts from sewage.

Environment—surroundings, including all living and non-living factors.

Environmental Assessment—a document prepared by the EPA on its assessment of the impacts of proposed projects.

Environmental Impact Statement (EIS)—detailed analysis of potential environmental impacts of a proposed project. It is required when the EPA determines that a project may have significant adverse environmental effects or is highly controversial.

Environmental Information Document—report done by the grantee describing the environmental effects of proposed wastewater projects.

Environmental Review—the process by which the EPA identifies and evaluates impacts upon the environment.

Erosion—the wearing away of land surface by wind or water.

Eutrophication—nutrient enrichment of a body of water producing excessive growths of aquatic plants that deteriorate the water environment.

Evapotranspiration Systems—systems which depend on evaporation and transpiration (loss of water from plants) for wastewater disposal.

f

Facility (201) Planning—planning local wastewater collection, treatment, and disposal facilities; the number refers to section of the Clean Water Act.

Filtration—process of passing wastewater through a granular bed or fine screen for removing suspended matter that cannot be removed by sedimentation.

Financial Management—the planning and administrative process by which financial resources are used in their most effective manner.

Five-Year Frequency Storm—storm of a certain degree of severity that is expected to occur on an average of every five years.

Flat Rate Structure—unit price of water is constant no matter how much is consumed.

Floodplain—a nearly flat plain along the course of a stream that is naturally subject to flooding at high water.

Force Main—sewer pipe under pressure from a pump to maintain the flow of sewage; used where gravity flow is not feasible.

g

General Obligation Bond—financial bond which is usually paid for by the community by raising taxes.

Gravity Sewer—collection system which relies on gravity to transport wastewater from homes to a central treatment or disposal facility.

Greenway—another name for "buffer zone."

Greywater—bathing, washing, and kitchen wastewater which is no longer potable, but can be filtered and used for other purposes.

Grit Chamber—a tank where sand, cinders, and small stones are removed from wastewater by settling.

Grit Removal—a stage of primary treatment during which sand, cinders, and small stones are removed from wastewater by settling out.

Groundwater—water lying below the surface of the earth.

h

Hardness—property of water that tends to cause scaling and inefficient use of soap; generally caused by the mineral calcium and magnesium.

Heavy Metals—metallic elements such as mercury, chromium, cadmium, arsenic, and lead with high molecular weights. They can damage living things at low concentrations and tend to accumulate in the food chain.

Holding Tank—tank used for storing wastewater prior to treatment, usually used as an alternative for onsite problem areas.

Horticulture—science of growing flowers, fruits, and vegetables.

House Connection—sewer that carries wastewater from the house to a collection system.

Hydraulic Overload—situation when a wastewater treatment plant is unable to handle the large flow of water entering it.

Hydrologic Cycle—the flow of water through the air, land, and liquid environments.

Hydrology—the science dealing with the properties, laws, and geographical distribution of water.

i

Impact Mitigation—the lessening of the effects of a project on the environment.

Implementation Cost—the cost to the community resulting from the use of selected mitigation measures.

Incompatible Waste—a waste that will 1) upset a treatment works; 2) pass through a treatment works and cause a pollution problem; 3) be removed in the treatment works, but interfere with the disposal of the sludge from the treatment works.

Increasing Block Rate Structure—cost of water to consumer increases as consumption increases, and at an increasing rate; also known as a penalty structure.

Industrial Closed Loop—the treatment and reuse of waters used in production within an industrial plant so that no water leaves the plant.

Industrial Pretreatment—treatment of industrial wastes before discharge to a municipal sewer system.

Industrial Waste Ordinance—a common instrument of legal authority for enforcing pretreatment programs.

Inequities—injustices or unfairnesses.

Infiltration—seepage of effluent through the ground to the water table, *or* groundwater leaking into cracked or broken sewers.

Infiltration and Inflow (I/I)—leakage of ground and surface water into sewers.

Infiltration-Percolation Land Treatment—the application of treated wastewater onto land to allow it to percolate downward through the soil in order to remove nutrients such as phosphorous and nitrogen.

Inflow—surface water that gets into the sewer system from storm drains, downspouts, and sump pumps often during periods of rainfall.

Influent—the raw wastewater entering a sewage treatment plant or in more general terms, the flow entering some process unit.

Innovative and Alternative Treatment—a nonconventional, cost or energy-saving system for treating wastewater; it may qualify for an increase in the federal grant share by 10 percent, from 75 to 85 percent.

Innovative Waste Treatment Systems—systems that, through new ideas and techniques, significantly reduce costs or use of energy, improve control of toxic materials, improve operational reliability, or result in some other public benefit.

Inorganic—substances such as metals or minerals that do not contain carbon.

Insoluble—material that cannot be dissolved in a liquid.

Interceptor Sewer—central sewer pipe which carries flows from the collector sewers in a drainage basin to the point of treatment or disposal of the wastewater.

Intrusion Barrier—practice such as injecting groundwater with effluent in coastal areas to force back intruding salt water.

Ion Exchange—exchange of one ion in water for another, specifically, exchanging ammonium nitrogen for sodium or calcium.

Irrigation—application of water to vegetation to improve its production.

j k l

Joint Treatment—treatment of both municipal and industrial wastes in a publicly-owned treatment works.

Lagoon—a pond containing wastewater in which organic wastes are removed under aerobic or anaerobic conditions.

Land Reclamation—the reclaiming and reuse of wasteland, swamps, marshes, and other unused or wasted land for useful purposes, such as cultivation or recreation.

Land Treatment—process of applying wastewater to the land for removal of pollutants; sludge (the solids removed from wastewater) also may be disposed on land, but it is not called land treatment.

Lateral—the small sewer serving individual streets.

Leachate—water flowing from the bottom or sides of dumps or landfills that contains material dissolved from the materials stored in the dump.

Leaching—process by which substances are dissolved and carried away by water, or are moved into a lower layer of soil.

Legal Authority—statutes, ordinances, contracts, or agreements through which a municipality enforces its pretreatment program.

Liaison—a go-between to ensure concerted action between parties.

Life-Line Rate Structure—schedule providing a minimum basic amount of water at a small cost to all people.

Limiting Zone—ground components such as impervious clay, rock, or the water table, which can render an area unsuitable for onsite disposal.

Linear Park—a park which is located along a route, such as a sewer right of way or a streamside easement.

Loading Rate—rate at which pollutants accumulate in soil or surface waters.

Local Pretreatment Program—a procedure for regulating the discharge of industrial waste to a publicly-owned treatment works.

m

Main—the intermediate-sized sewers connecting submains to plants or interceptor.

Metabolism—process by which food is built up into living protoplasm, and protoplasm is broken down into simpler compounds with the exchange of energy.

Methane—a gaseous by-product of the breakdown of organic matter in aerobic digestion.

Mitigation Measure—technique for correcting or minimizing adverse environmental impacts.

Mitigative Costs—the costs resulting from measures taken to lessen the impacts of a project on the environment.

Monetary Costs—costs which can be measured in real dollars.

Mound—a type of onsite disposal system utilizing an absorption field built on a bed of sand.

Mound System—a type of onsite disposal utilizing an absorption bed of sand that is above the natural grade of the soil surface.

Multiple Use—utilization of wastewater treatment facilities for other functions in addition to wastewater treatment, such as for recreational and educational purposes.

n

Nitrification—conversion of nitrogen-containing substances such as proteins into nitrates by bacteria.

Nitrogenous—containing the element nitrogen.

Notification—information flow from the governmental agencies to interested or affected parties; involves communication techniques such as fact sheets, newsletters, and seminars.

Nonpoint Source—a contributing factor to water pollution that can't be traced to a specific spot, such as agricultural fertilizer runoff or construction sediment.

Nonstructural Management Alternatives—nonphysical approaches to pollution control such as land use controls such as zoning ordinances, improved urban maintenance programs, and construction activity schedules. Often more effective and less costly than structural alternatives.

NPDES Permit—permit for discharge of a municipal or industrial waste issued by the EPA or state regulatory agency.

o

Onsite Disposal—disposal of wastewater on an individual lot, usually by a septic tank.

Onsite Recycle—filtered and/or chemically-treated water which flows from a holding tank back to the toilet for subsequent reuse.

Onsite System—a self-contained system which provides both treatment and disposal of wastewater on an individual lot.

Opportunity Costs—monetary value of potential benefits lost as a result of a water quality action.

Organic Matter—carbon-containing substance.

Organic Waste Discharge—waste normally containing oxygen-demanding carbon compounds.

Overland Flow—land application technique in which wastewater is sprayed onto gently sloping ground planted with vegetation.

Oxidation Pond—a natural or man-made pond where wastewater is processed through the interaction of sunlight, wind, aquatic organisms, and oxygen.

p q

Pathogen—disease-causing organism.

Pathogenic—disease-causing.

PCBs—polychlorinated biphenyls; a group of extremely persistent chemicals used in electrical transformers and capacitors.

Peak Demand Rate Structure—increases price of water at high consumption periods; effect of leveling out water usage.

Per Capita Daily Consumption—amount consumed per person per day.

Percolation—downward flow or filtering of water through pores or spaces in rock or soil.

Percolation Test—test for measuring the ability of soil to permit downward flow or permeability of water.

Permeability—the degree to which a substance is capable of being penetrated by water.

Permeable—quality of an aquifer that permits water to move through it.

pH—hydrogen ion concentration in a solution.

Point Source Pollution—pollution that is discharged from a single location such as a pipe.

Pollutant Loading—amount of pollution contributed by a given pollution source over a time period.

Polychlorinated Biphenyls (PCBs)—a group of toxic, persistent chemicals used in making transformers and capacitors.

Polymer—chemical compound consisting of repeating structural units.

Ponding (Parking Lot, Rooftop)—occurs when a structure is designed so that rain water will collect within its boundaries and will exist at a specific location at a controlled flowrate, rather than running off uncontrolled.

Porosity—open spaces or cracks in rock that might fill with water.

Precipitation—process where chemicals combine to produce a compound that can be easily removed from a solution.

Present Worth—the sum of money that must be placed on deposit at a given interest rate when the project construction begins to provide funds for the anticipated expenditures.

Pressure Sewer—collection system in which wastewater is pumped under pressure from homes into a central treatment or disposal facility.

Pretreatment—treatment of an industrial waste before discharge to a municipal sewer system.

Pretreatment Effluent Standards—concentrations or amounts of toxic chemicals that may be discharged to publicly-owned treatment works.

Primary Clarifier—sedimentation tank used for removing settleable solids during primary treatment.

Primary Impact—an effect directly related to a program or a project such as noise associated with the construction of a wastewater treatment plant.

Primary Waste Treatment—first stage of wastewater treatment; removal of floating debris and solids by screening and sedimentation.

Prohibited Wastes—wastes not allowed to be discharged to a publicly-owned treatment works.

Public Participation—involvement of citizens in the decision making process.

Pump Station—facility located along a sewer to maintain the flow of wastewater under pressure.

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Rapid Infiltration—land application technique in which wastewater is applied to land and is allowed to percolate through the soil and enter the groundwater, thereby treating the wastewater.

Responsiveness Summary—document prepared by a planning agency indicating briefly to the public how decision makers have dealt with the actions, comments, and opinions of the public.

Retrofit Devices—modifications to be installed on existing equipment.

Revenue bond—financial bond which the community pays for through fees for the use of a facility.

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Saline—containing chemical salts, such as sodium, potassium, and magnesium.

Salt Water Intrusion—the seepage of saltwater into fresh groundwater, often caused by overpumping the groundwater.

Sanitary Sewer—collection system which carries wastewater produced in homes and industry; a separate collection system carries stormwater runoff.

Sanitary Wastewater—refers to wastewater produced in homes and industry, and separate from stormwater runoff.

Saturated Zone—layer below the water table where all cracks and pores are filled with water.

Secondary Clarifier—sedimentation tank used for removal of settleable solids and scum created during secondary treatment.

Secondary Impact—effect indirectly caused by a program or project, such as community growth induced by wastewater treatment facilities.

Secondary Treatment—microbiological treatment of wastewater to consume organic wastes usually in the presence of oxygen. Floating and settleable solids, and about 85 percent of oxygen demanding substances and suspended solids are removed. Disinfection with chlorine is the final stage of secondary treatment.

Sediment Detention Basin—structural facility for temporarily storing stormwater runoff, during which time sediment is removed by settling.

Sedimentation—a nonpoint source of pollution caused when construction disturbs the soil and sediment is washed from the construction site and enters urban stormwater; also more generally, the settling out of solids in wastewater or stormwater by gravity.

Seepage Bed—type of absorption system which uses a wide trench partially filled with gravel or crushed stone and covered with soil. Piping distributes treated sewage evenly throughout the bed for seepage into the ground.

Separate Sewer—collection system which uses a sanitary sewer to carry only wastewater, and a storm sewer to carry runoff from rainwater.

Septage—the solids collected in septic tanks over many months of operation.

Septage Treatment—treatment of the solids collected in septic tanks over many months of operation.

Set Price Rate Structure—each group of customers pays a set amount for any amount of water consumed.

Sewer Interceptor—pipe which carries flows from the collector sewers in the drainage basin to the point of treatment or disposal of the wastewater.

Sewer Lateral—small sewer pipes in the street to which the individual users connect.

Silviculture—a phase of forestry dealing with the establishment, development, and harvesting of trees.

Sludge—concentrated solids removed from sewage during wastewater treatment.

Sludge Digester—heated tank where wastewater solids can decompose biologically and the odors can be controlled.

Soil Profile—a graphic representation of soil components.

Soluble—material that can be dissolved in a liquid to form a homogeneous material.

Special Assessment Bond—financial bond issued to pay for public improvements where specific and direct benefits exist; payments from parties who benefit retire the bonds.

Spray Irrigation—the application of treated effluent onto land by spraying to provide irrigation.

Stabilization—digestion of the organic solids in sludge so that they may be handled without causing a nuisance or health hazard.

Step One Planning—initial planning stage for water pollution control facilities as administered through the Construction Grants Program.

Step Two Design Grant—the second stage of planning when a water pollution control alternative is designed as administered under the Construction Grants Program.

Stream Divergence—altering and/or dividing the flow course of a stream to reduce the effects of high flows on the land surface.

Structural Management Alternatives—involve physical entities for delaying, blocking, or trapping pollutants. As compared to nonstructural approaches, they are often expensive.

Structural Methods—construction of physical entities for delaying, blocking, or trapping pollutants.

Submain—sewer connecting laterals to mains.

Subsidence Preventive—use of groundwater injection to prevent soil from subsiding or settling excessively.

Supernatant—the relatively clear liquid that forms on the top of the digested sludge in the second tank of a two-stage anaerobic digestion process.

Surface Water—accumulations of water on top of the ground, such as lakes, streams, and the oceans.

Suspended Solids (SS)—tiny pieces of solid pollutants in sewage that cause cloudiness and require special treatment to remove.

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Thickening—separation of as much water as possible from sludge by gravity or flotation techniques.

Total Dissolved Solids—the total amount of dissolved organic and inorganic material contained in water.

Toxic Chemical—one of a number of deadly substances; it appears on a list published by the EPA.

Transpiration—loss of water from plants.

Trickling Filter—a secondary treatment process where wastewater seeps through a film of microorganisms growing on stones or a synthetic medium. As the wastewater trickles through the media, the microorganisms metabolize most of the organic pollutants.

Turbidity—cloudy condition in water due to suspended silt or organic matter.

201 Plan—local plan for wastewater treatment facilities under the Construction Grants Program of the EPA; the number refers to a section of the Clean Water Act.

201 (Facilities) Planning—deals with the planning, designing, and construction of local wastewater treatment facilities.

208 Plan—regional, state or areawide plan for water quality management; the number refers to a section of the Clean Water Act.

208 (Water Quality Management) Planning—water quality planning with a state, regional, or areawide scope; provides guidance for individual 201 facility plans.

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Unit Processes—individual functioning parts of a whole system.

Unsaturated Zone—soil layers above the water table, where water adheres to soil particles and will not flow to a well.

User Charge (Fee)—prices charged to the consumers of various public services.

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Vacuum Filter—a cylindrical drum filter which uses a vacuum to separate the solids from the water.

Vacuum Sewer—collection system in which a central vacuum source maintains a vacuum on small-diameter collection mains.

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Wasteload Allocation—the maximum pollutant load that a facility is legally permitted to discharge to a water body.

Water Quality Management (208) Planning—planning for the maintenance of clean water at the state, regional, and areawide levels.

Water Quality Standard—levels of pollution parameters or stream conditions that must be maintained to protect desired uses of water.

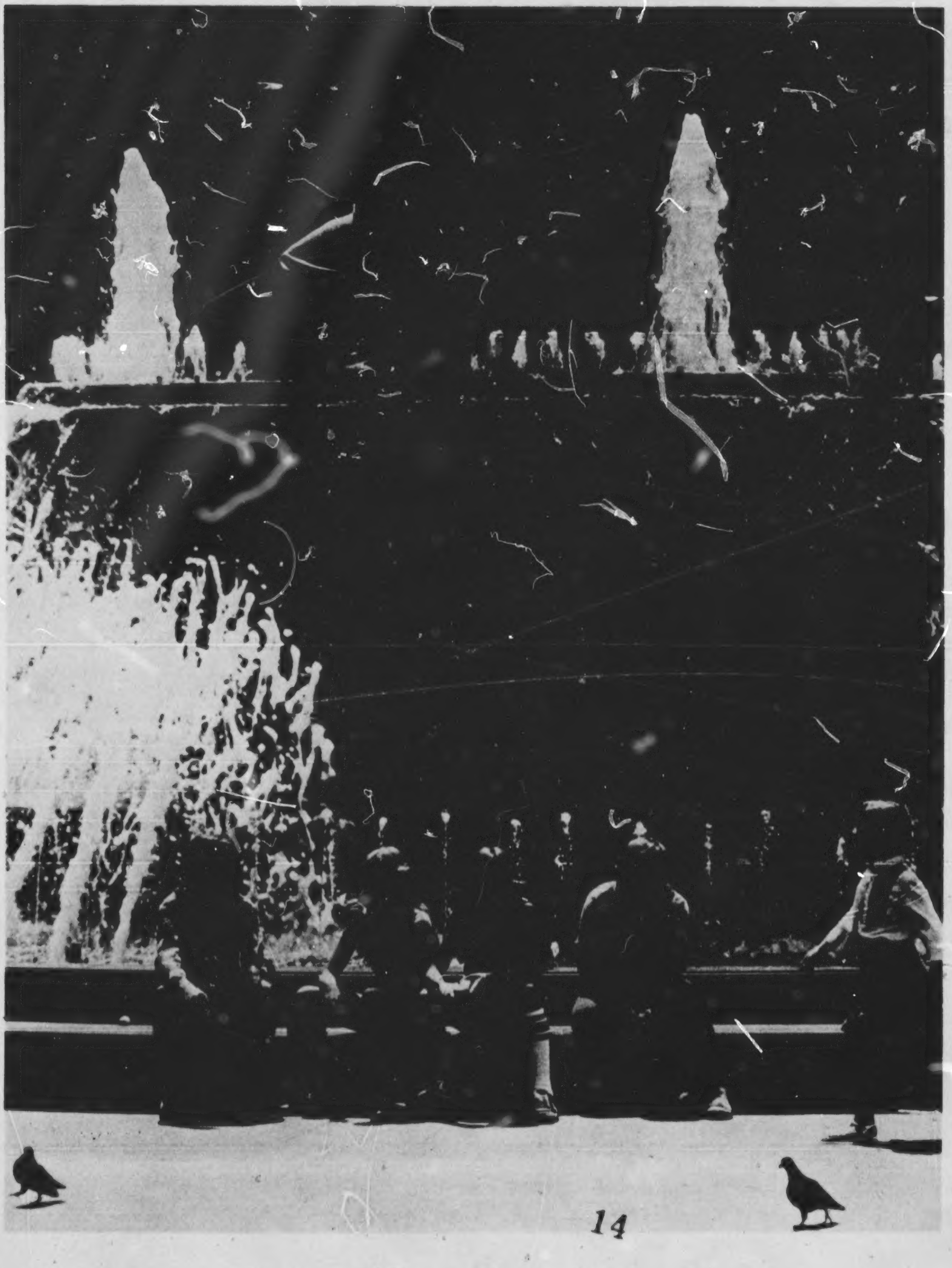
Water Recharge—adding water to an aquifer either by spreading on the ground surface or by direct injection through wells.

Watershed—the land area that drains into a stream or river.

Water Table—top surface of the groundwater.

Wet Air Oxidation—process of breaking down solids in wastewater under conditions of high temperature and pressure.

Wetlands—low-lying lands which frequently have standing water on them, such as swamps, marshes, and meadows. Wetlands essentially are pollutant traps in natural environments.



Chapter 13

Multiple Use

E. Drannon Buskirk, Jr.

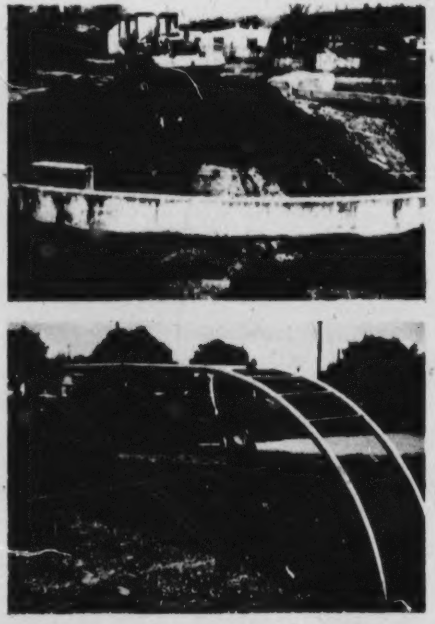
It doesn't make sense to some people. Spending millions of tax dollars to clean up wastewater is one thing. Spending these same funds on tour facilities, meeting rooms, and such matters, however minimal, is questionable. It is just another governmental boondoggle.

From another viewpoint it is foolish to miss opportunities. We must squeeze as many benefits as possible from public investments. Besides cleaning up wastewater, treatment facilities can provide recreation, open space, and resources such as environmental education. Rather than squander or divert water clean-up funds, multiple use of treatment facilities supports long-term water quality goals.

Adapting a wastewater treatment facility to other functions is called *multiple use*. It means extending a facility designed mainly for wastewater management to additional uses such as bike paths, ballfields, and greenways. It is not a multiple purpose project such as an incinerator, which from the outset is designed for burning both sludge and municipal refuse. Multiple purpose projects may be beneficial, but United States Environmental Protection Agency (EPA) Section 201 construction grants deal mainly with water pollution. The need for wastewater treatment facilities far exceeds available federal funds. Thus, these grants are limited to treatment works. On the other hand, *multiple use* developments that cost very little can achieve great benefits.

Why Multiple Use?

Without on-going public involvement, wastewater treatment plants at best are temporary solutions for pollution problems. Why? Such facilities left hidden behind chain link fences tend to break down from a lack of maintenance, or become overburdened from community growth. Unless these facilities are thrust into the mainstream of community life, most will fail. Multiple use is one way of dealing with the problems. Plants work better and stay cleaner when these facilities are used as community centers for multiple use activities. These persons become more aware of clean up efforts and situations that cause pollution. This knowledge builds support for water quality planning and decision making.



Conversion of an abandoned plant to a neighborhood park at Miamisburg, Ohio.

Before

After

Multiple Use Opportunities

Numerous opportunities exist for the multiple use of water and wastewater facilities. Rights of way, and treatment plant grounds and buildings offer options for multiple use.

Rights of Way

Sewer rights of way and streamside easements are ideally suited for many recreational and resource activities. In addition to providing parks, these routes may link neighborhoods, playgrounds, schools natural areas, and commercial centers through trail and open space networks. They often link a wastewater treatment plant and the community, contributing to awareness about the treatment facilities. Rights of way accommodate sports such as hiking, jogging, bike riding, horseback riding, snowshoeing, and cross-country skiing. These uses bring year-round recreational opportunities into populated areas where they are most needed, and an awareness and appreciation for clean water.

Sewer easements parallel to water bodies create other multiple use opportunities. Rights of way provide utility corridors for future water mains, gas lines and power lines. They facilitate maintenance through easy access along parallel roads. They afford access to the water's edge for fishing, boat launching, and swimming. As buffer strips they protect water quality and wildlife habitats from nonpoint source pollutants such as sediment, chemical fertilizers, and urban litter. These strips, sometimes called greenways, absorb the impact of flood waters and reduce property damages. They protect shorelines from new sources of pollution and preserve scenic settings for public enjoyment. Linear greenways have indirect environmental benefits; for example, biking along them cuts down the air pollution and energy consumption of auto use.

Finally, the developmental planning aspects of rights of way are pertinent. These linear arrangements shape community growth and open space patterns. Successful rights of way projects exist around the country.

Maryland. Ten miles of bike trail at Hyattsville have been built along a sewer line by the Washington Suburban Sanitary Commission. The sewer crosses park lands. The bike trail was built as a part of normal restoration work. Savings were realized because the trail design was incorporated into the plan for the sewer system.

New York. A hike and bike path in the town of Niskayuna connects the wastewater treatment plant with other recreation areas and points of environmental and historic interest. A neighboring town used the same path to locate a sewer.

Drainage and Sewer Rights of Way

Multiple Use Opportunities

- Linear parks
- Connecting networks
- Hiking trails
- Jogging trails
- Horseback riding trails
- Bicycle paths
- Environmental education
- Skiing and snowshoeing areas
- Future utility corridors
- Buffer strips for water quality protection

Treatment Plant Grounds

Most sewage treatment plants are constructed adjacent to water bodies. These locations are potentially useful for water-based recreation. Such activities as fishing, swimming, water-oriented picnicking, and boating (access ramps) can be provided in conjunction with treatment facilities. Other options exist.

Opportunities for active and passive recreation are needed by most communities. Wastewater treatment facilities can supply both at considerable land and money savings. Active recreational opportunities include playgrounds, ballfields, game courts, skating rinks, fish ponds, and small-game hunting areas. Passive recreational developments include parks, open space areas, and community gardens. Fences and the treatment plant staff provide the permanence and security necessary for uses such as community gardens and playing fields. One facility even has a weather station and an observatory for a local astronomy club.

Treatment plants provide opportunities for outdoor education. The grounds may be used for instruction on subjects such as natural history and archaeology.

Grounds also are used for activities that are possibly unsuitable for other locations. For example, recycling centers may be set up at treatment plants.

New York. The Coney Island Water Pollution Control Plant in New York City under a lease arrangement with the King's County Boys Club has a football field and bleachers, a roller-skating rink, and a clubhouse. At three other treatment plants in New York City fishermen use sludge loading piers for saltwater fishing.

Treatment Plant Grounds

Multiple Use Opportunities

- Skating rinks
- Swimming areas
- Picnic sites
- Fishing piers
- Fish ponds
- Boat launches
- Small-game hunting lands
- Parks
- Playing courts and fields
- Parks
- Playing courts and fields
- Outdoor education
- Community gardens
- Open spaces

Treatment Plant Buildings

Existing and Abandoned Structures

One approach to multiple use employs abandoned or unused physical structures. Another features additional applications of the wastewater treatment buildings themselves.

Abandoned plants save money two ways. They avoid the cost of new construction and demolition of the old facilities. Most of these old facilities are located in waterfront areas near population centers in need of recreational opportunities. Fishing piers and ice-skating rinks are suited to these waterfront locations. Around the country abandoned plants serve many uses, including: playing courts, adventure playgrounds, wading pools, and buildings for meeting rooms, recreation centers, and restrooms.

Of course, buildings do not have to be old or abandoned to serve such functions. Existing plants have community meeting rooms, public restrooms, and dressing rooms. The computer systems of some plants process data for other community activities such as tax records.

Educational Programs

Educational rather than recreational applications are a principal multiple use. *This is especially true in many urban areas where wastewater treatment sites and rights of way have little recreational or open space potential.* Educational opportunities at wastewater treatment facilities include:

- Citizen education
- School courses
- Career development.

Citizens have a right to participate in water quality planning. This mandate of The Clean Water Act requires an informed public. As a physical facility, a treatment plant can help educate advisory groups and other citizens about at least one of the alternative forms of wastewater treatment. A plant can be used to retrace planning decisions. It also can be a meeting place for advisory groups. It can be a repository for public review documents.

Education that is applicable to the real world is increasingly important. Wastewater treatment plants offer unique opportunities to observe relationships among treatment processes. Issues concerning environmental quality such as the costs of pollution control are more understandable in a treatment plant setting. Subjects such as biology, chemistry, and environmental issues are easily taught here.

Visits by students and other citizens to treatment plants increase the accountability of plant operations. They can actually improve plant efficiency and maintenance. Plant visits also help develop community support, and may lead to larger operations budgets. These facilities can provide an impetus for changed habits on water use such as water conservation.

The plants that have such programs have various arrangements for tour guides. These options include the use of volunteers, certified trainers, and operations staff with flexible work hours. Many facilities already conduct tours, but on an ad hoc basis. Neither the facilities are designed for, nor the staff are trained for these activities. Both the educational potential and plant operations suffer as a result.

Access to wastewater treatment plants enables students to view firsthand the possible career opportunities in water quality control. Educational benefits also are realized by treatment plant staff or agency officials. Educational programs can train staff or upgrade the skills of treatment plant operators.

Ohio. The children of Miamisburg today enjoy recreational facilities created from an abandoned plant at tremendous cost savings. An adventure playground was developed around a dismantled digester tank. Other equipment became a splash pool and a roller-skating area. Sludge beds were filled in and paved for basketball, volleyball, hockey, and tennis. An administrative building was converted into game rooms and restrooms.

Treatment Plant Buildings and Structures

Multiple Use Opportunities

- Environmental education
- Observation decks
- Astronomy observatories
- Weather stations
- Play areas
- Meeting rooms
- Dressing rooms
- Public restrooms
- Data processing centers

Cultural and Natural Resources

Multiple use opportunities are usually evaluated in terms of the main wastewater system components: treatment plant sites, buildings, and sewer rights of way. Other opportunities of a resource character exist. They include both cultural and natural resources such as agricultural, aquacultural, and energy products.

Archaeological and historical artifacts and information are turned up in planning and constructing wastewater treatment facilities. These resources can be displayed in visitor areas of a plant. Historical markers can be placed along a right of way. Such efforts add educational value to a facility. In certain circumstances, barge canals, towpaths, or water mills can be preserved by sharing site acquisition costs with water clean up funds. Similarly, treatment plants also afford protection for sensitive environmental areas such as wetlands, forests, and historical sites.

Effluent and sludge nutrients have been used by farmers for decades. However, only in recent years has research tested the cost effectiveness and safety of the approach. Although caution must still be exercised with metal-containing sludges, vast potential exists. At plants around the country the nutrients are used in growing crops and fish, and in reclaiming soils depleted of their organic (carbon-containing) matter and nutrients. Park lands are similarly restored.

Energy production is another option for wastewater treatment facilities. Methane is a by-product of the breakdown of organic matter by bacteria in the absence of oxygen (anaerobic digestion). This gas is a fuel that can be used in the plants themselves, or it can be sold to residential and commercial users. Potential exists for additional methane production from the further breakdown of organic sludges. Some plants are also exploring the possibility of generating electricity by small hydropower turbines on interceptor pipes, or co-generation by sludge incineration.

Other opportunities most certainly exist. They will continue to be discovered and developed. The first step is a willingness to explore them.

Georgia. Surveys for a right of way along the Chattahooche River near Atlanta uncovered important archeological sites. 5,000 year-old Indian rock shelter villages are the subject of continuing exploration by archeologists and high school students.

Texas. The Walnut Creek Treatment Plant in Austin features multiple uses in an environmentally-sensitive neighborhood. The facility stops odors with activated carbon filters, and controls noise with earth berms and buffer walls. Meeting rooms, a fishing lake, and picnic areas are available for public use.

Cultural and Natural Resources

Multiple Use Opportunities

- Cultural and historical preservation
- Agricultural production
- Aquacultural production
- Land reclamation
- Methane production
- Small-flow hydropower generation or co-generation
- Greenways and wetlands

Planning Strategy

Many agencies participate in planning multiple use activities, especially recreation. The EPA, the Heritage Conservation and Recreation Service (HCRS), the Department of Housing and Urban Development, and other agencies have multiple use interests. At the federal level two EPA programs in wastewater management are of particular importance—208 areawide planning, and the 201 construction grants program.

Water quality management 208 plans have a broad, regional scope. They provide the umbrella under which individual facility plans are formed. These plans can coordinate multiple use programs among the treatment sites in an area. Thus, rather than every facility having particular educational or recreational programs, the 208 plan may systematically call for services at particular plants according to transportation, location, facility uniqueness, and other considerations. These plans can coordinate water and recreation investments to save on acquisition and development costs. Finally, 208 plans also involve other factors pertinent to multiple use opportunities such as strategic open space areas, nonpoint sources of pollution, wetlands, and greenways.

The 201 program provides for the planning (Step 1), design (Step 2), and construction (Step 3) of new or expanded wastewater treatment facilities. A preapplication stage precedes the formal planning sequence. Multiple use inputs are especially significant in the preapplication and planning stages. Multiple use efforts are important at several points:

- Selection of consultant
- Preapplication conference
- Fact sheet
- Information meetings
- Preparation of facility plan and public hearing
- Reviews of project plans and specifications.

The advisory group may not be involved at the beginning of the process. However, the selection of the consultants and the sewage commissioners is very important.

Persons with an interest in multiple use are more likely to incorporate such considerations into the plans. The preapplication conference sets the tone for the planning effort. It is crucial at this point to show local interest, and to start the grantee and consultants thinking about multiple use options.

Multiple use inputs are appropriate throughout the planning stage. Multiple use can be an agenda item at meetings. Advisory group subcommittees can be formed to study options and local interests such as the Little League that can be served. Group members and the public can take tours of existing plants to see multiple use in operation. Frequent news releases about multiple use can interest diverse publics in wastewater treatment facilities, and establish on-going support. However, this does not mean that multiple use should be used to sell treatment plants. Projects first and foremost must be environmentally sound, cost effective, and technically feasible.

All planning begins with needs assessment. In addition to wastewater management needs, recreation, open space, and other needs suitable for multiple use are identified. Recreationists and other persons with multiple use interests should be invited to provide input on a regular basis. These persons should be advisory group members on full-scale public participation projects. The grantee is required to help identify these parties.

A fact sheet, including cost information, on a project is released to the public early in the planning process. Multiple use can be included in this document to both solicit ideas and drum up support.

The Step 1 facilities planning process requires at least one public meeting, as well as a public hearing, on the proposed facilities plan. Informational meetings, especially in assessing community needs, are good places for discussions about multiple use. They present an opportunity to make the multiple use benefits known to the public, and to hold consultants accountable for multiple use analyses. Since a responsiveness summary of all meetings and hearings figure significantly in EPA and state assessments, voicing concern for multiple use at these points are important. The review of final plans and specifications is an additional opportunity for insuring that multiple use is actively considered.

Even after the facility is under construction it is not too late to incorporate multiple uses. Although these options are limited, certain uses are feasible; for example, grading lands may accommodate recreational uses.

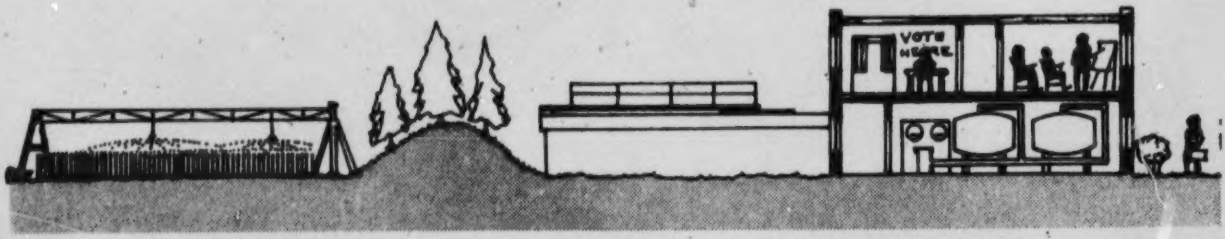
A Word of Caution

Some persons think that multiple use should not be involved throughout the planning process. Here, multiple use comes into consideration only after the most cost-effective alternative is chosen.

This approach is *wrong*. Multiple use, or any other planning element, should not be tacked on the end of the process. Such an action invites the design of inflexible, underused facilities. A portion of the planning funds is available for dealing with community objectives other than wastewater treatment. In the long run, nearly all of these objectives, including recreation, serve in the clean up of water.

Factors of Open Space and Recreation Planning

- Public open space, recreation, flood control, and nonpoint source pollution control
- Environmental education
- Proximity to existing facilities
- Surrounding land uses
- Environmental and aesthetic features
- Compatibility of area with proposed uses
- Proximity to public access, public transportation, access barriers, and parking spaces
- Need for fencing, lighting, and play area surfacing
- Maintenance and security considerations
- Facilities design and site layout
- Topography, soils, drainage, and flooding characteristics
- Wind and sun orientations
- Water characteristics



Spray Irrigation Buffer and Screen Meeting Room and Polling Place

Challenges and Needs

Multiple use programs are not always easy to implement. Some considerations are given in Green Spaces and People Places, a manual prepared for EPA Region II. The following discussion is adapted from this document.

Multiple Use Coordination

The success stories to date are mainly the result of the efforts of a single person or organization to bring together numerous agencies, volunteer groups, and schools. At various places, these persons have been a plant operator, the director of a sewer district, the head of a local environmental commission, an official within the EPA or HCRS, or some other party. In each case, these people have been hampered by lacks of funding, legal authority, or clear procedures to follow. The Clean Water Act of 1977 places an enforceable responsibility on the grantee, the local wastewater management agency, to play the coordinating role, or to subcontract it. **Multiple use activities are best done when specific parties are given responsibilities, and adequate resources are delegated. Advisory groups can suggest such matters to the grantee.**

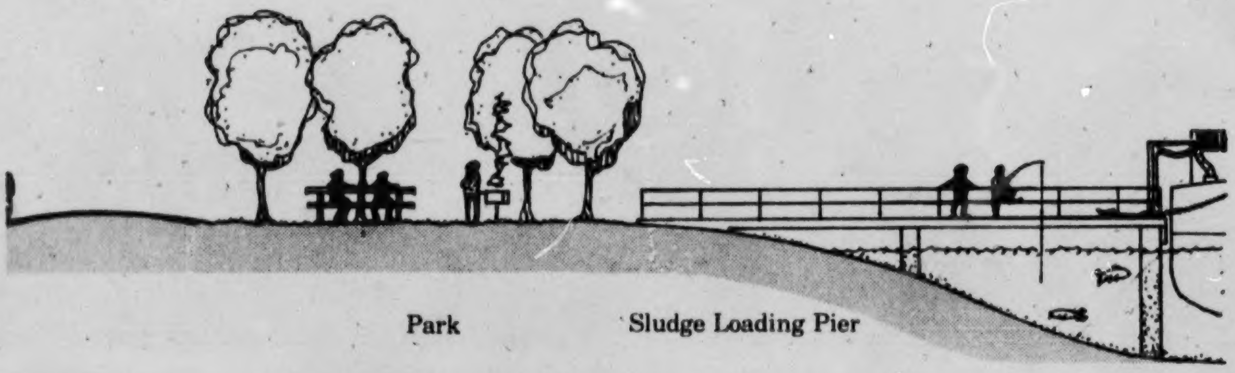
Property Acquisitions

Public access to land, or incentives to retain land for open space, can be achieved through various means. The most common ways are purchase or donation, lease, and easement. Their application to multiple use may run into snags.

Single-function agencies such as sewer authorities may be restricted by state law from acquiring lands for purposes other than those for which the agency is created. However, some legal opinions maintain that no conflict exists if the primary function of an acquisition serves the agency, and the secondary one does not interfere with the primary use. For example, a maintenance road serving a sewer right of way can double as a paved bicycle path without diminishing its primary purpose. Instead of land purchases, agencies can receive property donations in exchange for tax breaks. Other options include leases and easements.

Easements granted by private property owners to sewer authorities for rights of way may pose other challenges. The easements, obtained at considerably lower cost than outright purchase, often carry conditions such as limitations on public access. If a multiple use plan is developed long after easement agreements are sealed, renegotiating the easements can prove troublesome and increase costs. Early planning and simultaneous actions can reduce this problem.

The objective is not to let a few properties stop a project. The management agency has to maintain flexibility, and route around trouble spots. For example, for a bike trail in New Jersey a temporary land bank was formed until purchase funds were available.



The advisory group can make the grantee aware of these concerns. It also can help develop community support for property acquisitions.

Technical Assistance

At present, EPA policy does not permit funding for detailed design in multiple use projects. However, some features are eligible for preliminary design if they are ancillary to the treatment system itself, and they do not reduce the cost-effectiveness of the treatment facility. Design also is reimbursable if the HCRS funds outdoor recreation or open space options.

Other design alternatives exist.

The advisory group can assure that these matters receive the attention they deserve. The most perfectly designed system will not work if it is not maintained!

However, care must be taken so that these designs are not considered unnecessary frills that can be eliminated through subsequent value engineering studies. Often neighboring architectural schools can make designs as class projects. Volunteer and in-kind services and donations also are possibilities. The trick is imagination and cooperation. The Miamisburg, Ohio, renovation of an abandoned plant was designed entirely by city parks personnel.

Operation and Management Responsibility

A universal concern centers around the responsibility for operating and managing multiple use programs. In the case of educational activities at a treatment site, the sewerage authority can usually maintain the physical features. However, the participating educational or environmental institutions must undertake programs of organizing tours and developing educational resources. Tour leaders can be retired plant operators, or persons who undergo trainee workshops.

In the case of recreational development, some plants maintain grounds and picnic tables as part of normal maintenance. Where intensive public use of boat ramps, fishing piers, playing fields, and bike and hike trails occurs, other arrangements are necessary. Recreation groups must provide for maintenance, supervision, and security. These responsibilities may be spelled out in cooperative or lease agreements.

Sometimes volunteers, clubs, or recreation associations can perform these services. At a sludge pier used for fishing in New York City, a group of local fishermen reduces vandalism by monitoring the area and educating other users on expected standards of behavior. Elks Clubs and boy scouts provide and maintain picnic tables at sites around the country. In portions of New Jersey and New York, trails along rights of way that meet the standards of hiking associations may qualify for maintenance services.

Advisory groups can encourage the grantee to explore various management arrangements.

Where the Bucks Start

Paying for multiple use facilities is complex because of the wide range of use options and funding sources. Potential contributors are both private and public. Most funds are restricted to particular multiple use activities.

Private Sector Assistance

Potential sources in the private sector include:

- Businesses and corporations
- Service groups
- Foundations.

Donations to public recreation are attractive to business persons because of the tax advantages and the boost to business images. Gifts may also be a way for companies to mitigate public relations problems. Businesses may give materials, money, or the services of administrators and technicians.

Service groups and vocational schools are especially helpful in providing manpower for construction, maintenance, and publicity. Since these organizations reach the heart of the community, they also are important in establishing a public support base.

Federal Funding Alternatives

Federal agencies provide technical assistance and full or partial grants for multiple use. The EPA, the Department of Interior, and other organizations are funding sources, but funding levels vary from year to year. Many federal funds are channelled through state agencies. States often have programs which correspond to federal programs, especially those that offer matching grants.

As compared to private sources, the federal grants usually have more guidelines and regulations. Still, there is much potential for the use of federal funds by state and local organizations. Funding possibilities are not always obvious. For example, Tow Path Trail in New Jersey may qualify for historic preservation funds.

Environmental Protection Agency

Although the EPA does not provide design or construction funds solely for multiple use projects, these funds can serve as seed money for multiple use considerations. The EPA provides multiple use planning funds for all new wastewater treatment projects as a part of facilities planning. However, no funds are awarded for design or construction where the multiple use features are not an integral part of the facility. Facilities can serve the dual functions of multiple use and wastewater treatment. For example, an educational center for the public can be housed in the same room used for staff training. Walkway railings can be considered a necessary feature for plant personnel as well as the visiting public. Right-of-way

Sludge loading pier used for fishing in New York City.

Sources of Funding

Use	*Funding Legislation or Program*
Outdoor recreation, open space, fish and wildlife habitats	Heritage Conservation and Recreation Service Fish and Wildlife Service Soil Conservation Service
Historic and cultural preservation	National Historic Preservation Act of 1966 Community Education, Recreation, and Cultural Services Act
Bikeways and walkways	Federal-Aid Highway Act of 1973 Comprehensive Employment and Training Act
Environmental education	Environmental Education Act of 1972 Community Education, Recreation, and Cultural Services Act Sea Grant Program
General activities	Housing and Community Development Act of 1974 Comprehensive Employment and Training Act Farmers Home Administration loans Environmental Protection Agency

trails can serve both pedestrians and sewer maintenance personnel.

Department of Interior

The Department of Interior has several pertinent programs. The Heritage Conservation and Recreation Service administers the Land and Water Conservation Fund (LWCF), which provides matching monies for the planning, acquisition, and development of outdoor recreation facilities. The Fish and Wildlife Service provides funds for fish conservation programs, and technical services on multiple use projects. The Historic Preservation Fund enables matching grants for historical preservation surveys and plans, and the acquisition of endangered historic properties.

Other Federal Opportunities

Numerous opportunities for multiple use funding exist elsewhere. The Soil Conservation Service provides both grants and technical assistance for developing land and water resources. Environmental education projects are funded by the Department of Education under the Environmental Education Act. Funding for bikeways and pedestrian facilities is available from the Department of Transportation under the Federal-Aid Highway Act of 1973. Even Comprehensive Employment and Training Act (CETA) funds can be used for activities such as constructing trails and paving bikeways. These are only a few of the opportunities.

Getting On with It

Advisory groups can play significant roles in incorporating multiple use in areawide or facility planning. In *assisting* the grantees, advisory groups should:

- **Become familiar with the multiple use needs of the community. An inventory of the local situation, and aspects of educational, recreational, open space, and resource opportunities should be taken into account. An advisory group subcommittee can focus upon these matters.**

- **Encourage the grantee to integrate multiple use activities with other plans in the area, including the 208 water quality plan, the HUD 701 open space plans, and the Statewide Comprehensive Outdoor Recreation Plan (SCORP).**

- **Make sure that local needs and viewpoints are part of SCORP and the state's evaluation for Heritage Conservation and Recreation Service funding. Overlapping advisory groups can help in this effort.**

- **Help coordinate (1) multiple use implementation, such as negotiating the sewer rights of way and trail easements at the same time; (2) funding sources, such as submitting a Land and Water Conservation Fund application at the same time the project is placed on the state priority list for EPA funding. Advisory groups are especially sensitive to local sources of assistance.**

- **Insure that multiple use aspects are introduced at appropriate places throughout the planning process. The facility preapplication conference, plan preparation, fact sheet, public hearing, and project reviews all are appropriate points. Multiple use can be the topic of public meetings, newspapers, and mailings. Advisory groups can form subcommittees for studying multiple use. Written statements can be entered into the record of public hearings. Other options exist.**

- **Help arrange for technical assistance from various sources, including governmental agencies, private organizations, and the public. Advisory groups can be particularly effective in procuring assistance through interest groups, professional organizations, and personal contacts.**

- **Foster cooperation and communicate information among water-education-recreation constituencies about multiple use opportunities and the programs. Advisory group meetings can be a place for receiving planning inputs such as the ideas of recreation planners.**

Multiple use, thus, offers a lot more than is first apparent. It provides new resources such as recreation. It saves resources such as the operation and maintenance costs of treatment plants. It is no significant drain on wastewater facility funds. In fact, it fits into the long-term goals of the Clean Water Act to make lasting solutions to water pollution. Multiple use also is mutually supportive with public participation. While helping the public relate better to facility planning, it helps build public interest. Multiple use is not a minor concern to be tacked on the end of the process. It is in the mainstream of areawide and facility planning.

Case Study

Multiple Uses for the New and the Old

Naperville, Illinois

Adapted from Pfortner, Raymond, "Treatment Plants Can be People Places." Clearwaters. *March 1978. pp. 6-8.*

The City of Naperville, a suburb of Chicago, opened a regional wastewater treatment facility in the summer of 1977. Because of thoughtful planning from the outset, the facility has literally become the center of activity for the city's residents.

Buffer lands around the site are leased to the Naperville Park District for recreational use. The site offers community garden plots used by 300 families each season, and a popular canoe launch onto the DuPage River. A Future Farmers of America experimental farm tract is located at the site where the usefulness of sludge for growing crops is studied. The facility also houses an official weather station and a local astronomy club's observatory.

Some of the best activities at Naperville are inside the plant, and are educational rather than recreational. The treatment plant is designed and constructed for tours by school children and the general public. The plant features a raised observation deck for an overview of the facility. It has a multi-purpose room for staff training, group orientations, and community meetings. The plant also is an official polling place to encourage public use.

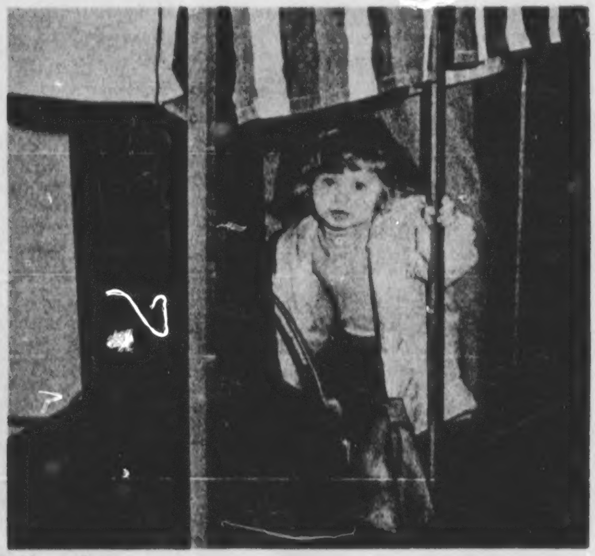
In constructing this facility four small treatment plants were abandoned, but some old facilities were recycled. An old storage tank was cleaned and relocated on the new site, where it provides water for the community gardens. One of the administration buildings was gutted and made into the city's data processing center at considerable savings over the cost of new construction. Old aeration tanks were sand-blasted, and are now used for water supply storage. A large trickling filter and control buildings at the old Naperville sites still have recreational potential.

All these activities are conducted at the Naperville plant without the loss of operational efficiency. The 10 mgd plant puts out an extremely high quality effluent, in the 3-4 mg/L BOD and suspended solids range.

The Director of the Naperville Water and Wastewater Utility Department attributes the success of the facility to cooperation and professionalism of all of the city departments. He says the design engineers who came up with the plant's land use plan were instrumental in the success of the project.

VISITORS OBSERVATION
DECK
PROCESS UNITS

Observation deck.



Polling place.

Need More Information?

Fulfilling Recreation and Open Space Requirements in Water Quality Management Planning. Nos. 1 and 2. Washington, DC: Heritage Conservation and Recreation Service, U.S. Department of the Interior. 1979. 8 and 11 pp.

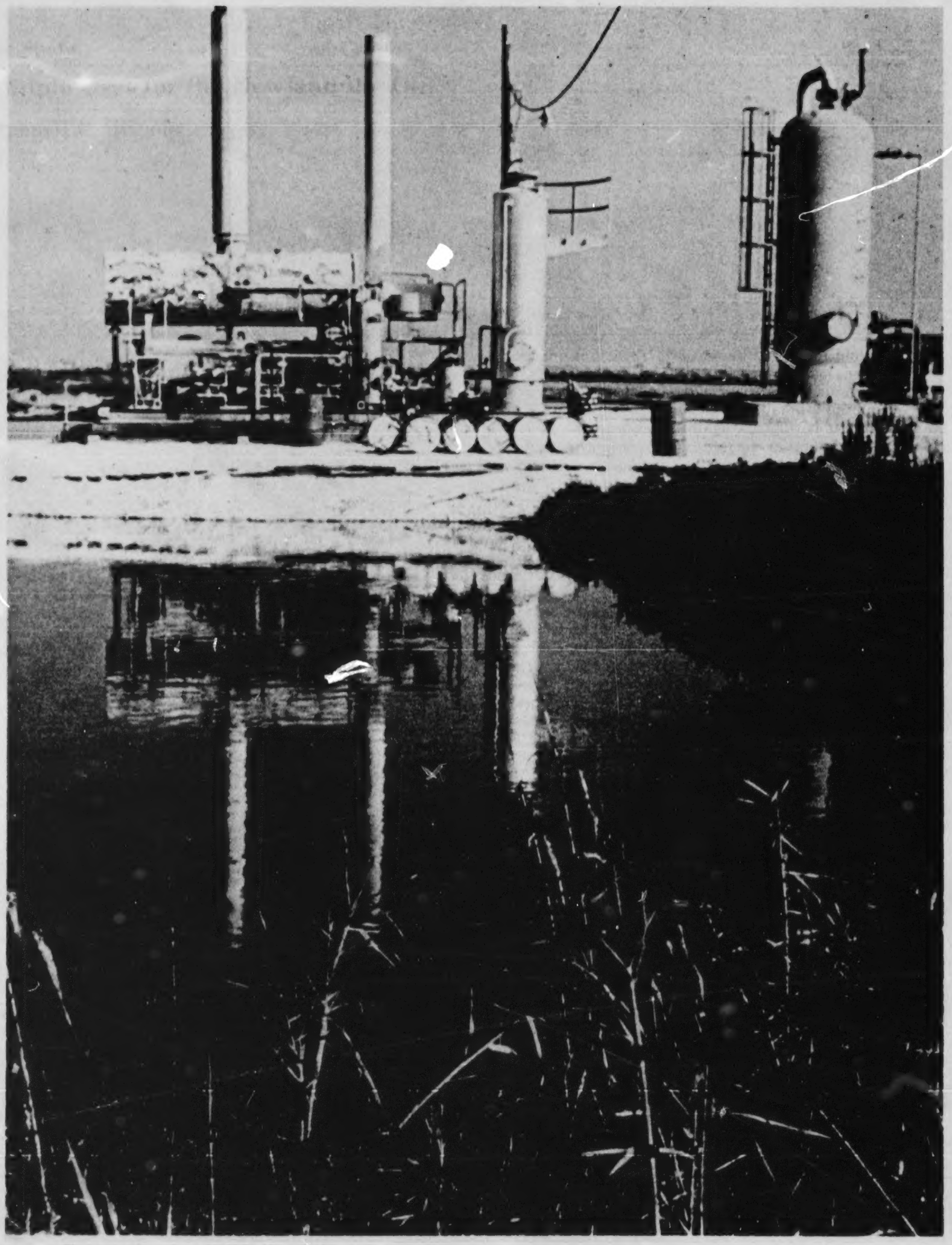
> These booklets deal only with the range of considerations involved in recreational and open space aspects of multiple use planning. In a question and answer format, Section 201 of the 1977 Clean Water Act is defined, funding and sponsors are discussed, and multiple use opportunities are outlined. Aspects of evaluating recreation possibilities for facility planning, design, and construction are covered. Both booklets have charts of funding assistance. The addresses and telephone numbers of agency offices also are given. Copies of the booklets can be procured from the Heritage Conservation and Recreation Service, 440 G Street, NW, Washington, DC 20243.

Green Spaces and People Places: A Manual on the Multiple Uses of Wastewater Treatment Plants. New York, NY: U.S. Environmental Protection Agency, Region II, 1978. 38 pp.

> This manual is an excellent document that mainly covers the rationale for multiple use, the successful experiences of plants that have done it, the needs and problems that have been experienced, available funding, and how to go about multiple use planning. Other sections list contacts, and give information sources. Appendices summarize relevant portions of the Federal Water Pollution Control Act of 1972, and provide a sample lease agreement. The manual is strongly oriented to the situations and needs in EPA Region II. The manual is available from the EPA Region II Office of Public Affairs, 26 Federal Plaza, New York, NY 10007.

Public Benefits from Water Clean-up. Washington, DC: Office of Land Use Coordination, U.S. Environmental Protection Agency, 1978. 41 pp.

> This booklet was written by the National Recreation and Park Association for the EPA. It abounds with a mixture of success stories, policy discussions, and the recreational planning criteria for sewer rights of way, treatment plant and lift station sites, and environmental education programs. It also covers funding sources, and implementation aspects. An appendix features a detailed discussion of legal considerations. It has ample planning illustrations and pictures. The booklet has not undergone widespread distribution. Photocopies are available at cost from the Office of Land Use Coordination, U.S. Environmental Protection Agency, 401 "M" Street, S.W., Washington DC 20460.



Chapter 14

Industrial Pretreatment

John B. Nesbitt

Is there an industry in your municipality that discharges manufacturing wastes into the sanitary sewer system? Do toxic industrial wastes complicate the operation of your wastewater treatment plant? Is industry failing to pay for its fair share of the treatment plant operating costs?

If the answer to any of these questions is yes, this discussion is for you.

Business is an important part of America's lifestyle. Although it makes possible a high material standard of living, it can produce wastes which are toxic to both surface waters and treatment plants. Each of these three systems (business, surface waters, and treatment plants) is sensitive in its own way to various influences. A healthy society needs all of them. The problem is to manage them together. The issues to be addressed in this balancing are:

- Roles of local, state, and federal governments
- Safety factors built into waste disposal systems
- Effective regulatory agencies
- Long term administrative and financial commitments by regulatory agencies.

The public has several concerns about industrial wastes. They include:

- Environmental impacts of land uses
- Groundwater pollution from industrial wastes
- Air pollution and odors
- Noise
- Silting and sludge disposal
- Safety and health.

These important concerns can be dealt with in several ways.

Industrial Waste Treatment Options

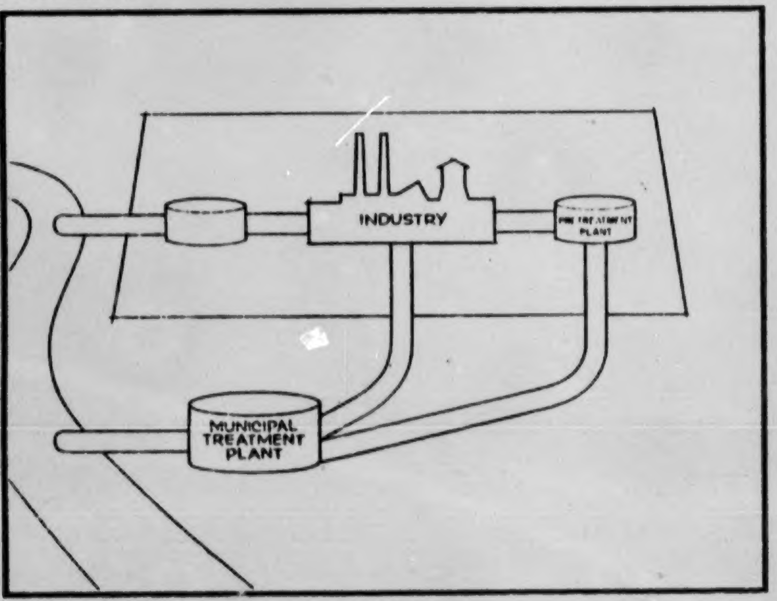
Industry has three major options in treating and disposing of industrial wastewaters:

1. Treat the wastewater in its own facility, and discharge it directly into the receiving waters (direct discharge)

2. Discharge the wastes to a publicly-owned treatment works that can treat both industrial and municipal wastewaters (indirect discharge, joint treatment)

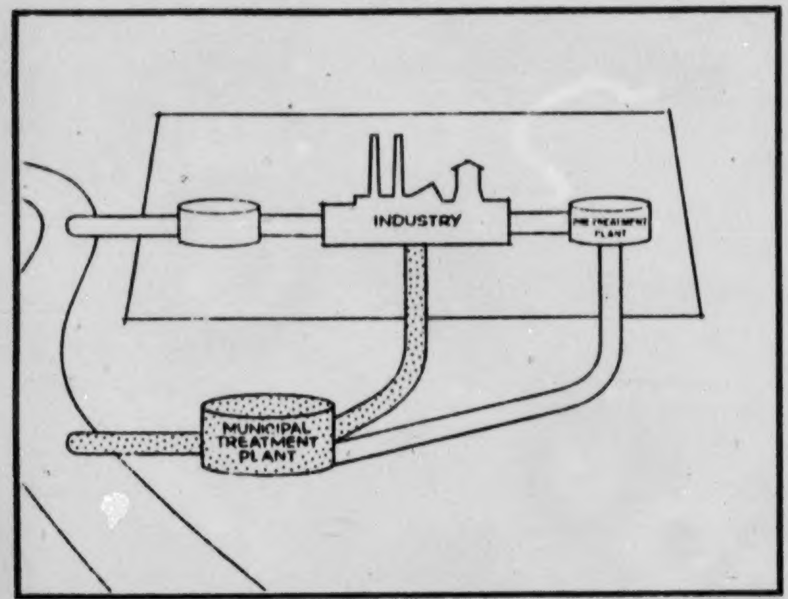
3. Pretreat the wastes to remove pollutants that would cause problems with the municipal treatment processes, and then discharge them to the municipal plant for joint treatment (indirect discharge, joint treatment).

An industry may treat its own wastewater and discharge it directly to surface waters.



Direct Discharge

If an industry treats and discharges its wastewaters in its own facilities, it must obtain a National Pollution Discharge Elimination System (NPDES) permit. It will be responsible directly to the regulatory agency in meeting the conditions of the permit. Therefore, pretreatment regulations are unnecessary and inappropriate for plants that treat only sanitary wastewaters.



An industry may discharge its wastewater to a publicly-owned treatment plant which has the ability to jointly treat the municipal and industrial wastewaters.

Indirect Discharge (Joint Treatment)

The other two options involve the joint treatment of municipal and industrial wastes. With joint treatment, an industry can discharge its wastewater to the municipal treatment plant for total processing, *or* it can first pretreat its waste and then discharge to the municipal plant for final processing. In both cases, industrial wastes are considered to be indirectly discharged to the receiving water, since the final treatment occurs in the municipal plant.

Joint treatment has advantages for both the municipality and the industry. The economy of scale in building a larger plant can reduce capital and operating costs. Administrative costs are lowered by the reduced number of direct discharges. Land resources are used more efficiently. Also the treatment processes may have increased reliability and flexibility.

The main disadvantage of joint treatment without first pretreating the industrial waste is that some industrial pollutants interfere with treatment processes in the municipal plant. Cyanide is an example of a pollutant that is toxic to microorganisms used in biological treatment methods. Treatment plant processes can be overloaded by an excess of organic matter or suspended solids. Certain toxic pollutants, such as the metal cadmium, cause the sludge to be unsuitable for land disposal. Still other pollutants, such as chlorides, pass through the treatment plant without causing interference, but may violate water quality standards for receiving waters. All of these pollutants are said to be incompatible with, or to upset, treatment processes.

The NPDES permit for an indirect discharge is issued only to the municipality which has the responsibility to see that industrial pollutants do not cause the permit to be violated. A well-conceived pretreatment program can assist the municipality with this responsibility. A program which requires an industry to pretreat its wastes will protect the municipal treatment plant and sewers from incompatible wastes. It will also allow the municipality to prosecute an industry that continuously or intermittently discharges incompatible wastes.

The Pretreatment Program

Legislation enacted by Congress requires the United States Environmental Protection Agency (EPA) to see that effective pretreatment programs are established. The EPA mandate involves two actions:

- Establish pretreatment effluent standards for industrial wastes, paying particular attention to toxic pollutants
- Require certain municipalities to develop local pretreatment programs capable of enforcing the national and local pretreatment standards.

Pretreatment Effluent Standards

The EPA is developing industrial pretreatment standards for specific toxic pollutants. These standards concentrate on about 125 priority pollutants in 34 industrial categories. The standards are uniform for a particular industrial category, and thus are called categorical standards.

Effluent standards for prohibited pollutants apply to all industries. Although these prohibited discharge standards are general, municipal pretreatment programs must have specific local prohibitive limits. This is to protect wastewater treatment plants from interference by the pollutants.

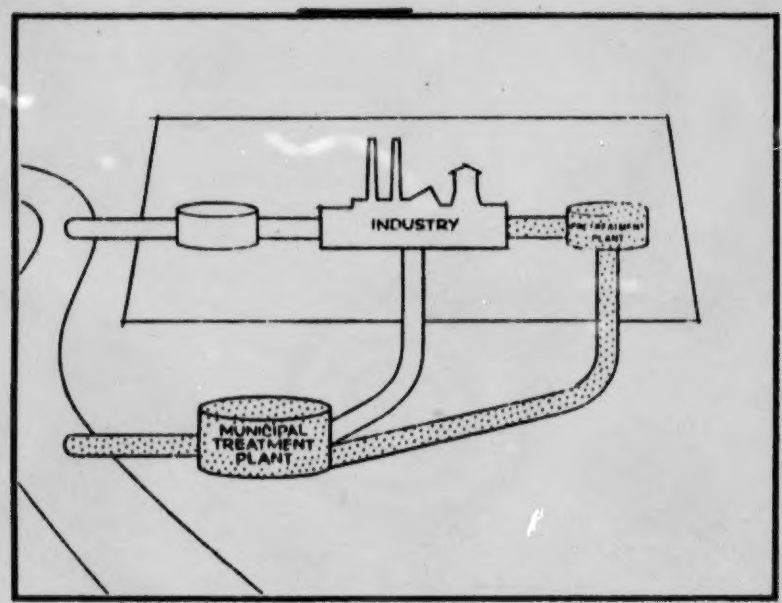
Pretreatment Regulations

Pretreatment regulations have been in effect since mid-1978 as the EPA General Pretreatment Regulations (40 CFR Part 403). These regulations were proposed again in October 1979. They establish the framework for municipal standards. They specifically:

- Apply whether or not the municipal wastewater treatment plant is federally funded
- Contain prohibited discharge standards to prevent the introduction of substances which are hazardous, dangerous, and otherwise incompatible with treatment plants
- Require the EPA to have certain municipalities develop local pretreatment programs
- Describe minimum requirements for local programs and approval procedures
- Describe industrial responsibilities under categorical pretreatment standards
- Outline the rules whereby industry may receive credit for removal of pollutants in the municipal treatment plant.

The development of a pretreatment program is eligible for 75 percent federal funding with both 201 and 208 grants. The pretreatment program was to be developed as part of 208 planning, but since regulations were published at a late date, it was made an eligible cost in 201 grants for all steps of the Construction Grants Program.

The proposed pretreatment effluent standards and the general pretreatment regulations are very recent actions of the EPA. These areas have been challenged in the courts. Further litigation will probably occur. Therefore, changes in both areas are expected. Consulting engineers should be familiar with the most recent information.



An industry may pretreat its wastewater before discharging it to a publicly-owned treatment plant where the industrial and municipal wastewaters will then be jointly treated.

Program Requirements

Approval of a pretreatment program by the EPA requires these actions:

- Community involvement is encouraged
- Local legal authority is established and evaluated
- Procedures for compliance with the program are developed
- Resources to carry out the program are obtained
- An organizational structure is developed
- An industrial waste survey is conducted
- If desired, the authority to revise categorical standards is obtained
- Variances from categorical standards, because of unusual manufacturing processes, are sometimes determined
- A detailed description of the pretreatment program is submitted to a regulatory agency for review.

Community Involvement

An important element in a successful and effective pretreatment program is its credibility in the community. The involvement of both the public and industry is essential. Local considerations play an important role in administering and enforcing a pretreatment program. Open communication among the various participants fosters trust. Active and informative community involvement can minimize enforcement conflicts. Industrial awareness of the nature, intent, and sincerity of the pretreatment program can encourage cooperation.

Before approval by the control authority, as a minimum, a description of the pretreatment program is made available to the public. Therefore, public involvement is not only a good idea; it is required by the EPA.

The following techniques can be used to develop and maintain the program:

- Public workshops
- Industrial meetings
- Advisory committees
- Mailing lists
- Media such as newspapers, television, and brochures
- School educational programs.

Advisory Group Questions in Facility Planning

1. Assessing Current Situation

What industrial users do we have?
What other industries do we have?
How much treatment capacity do they need?
What problems might they cause?

2. Assessing Future Situation

What industries are expected to move into the area?
What expansion is anticipated for existing industries?
How much treatment capacity is needed? When is it necessary?
What problems might they cause?

3. Identifying Alternatives

What alternatives provide maximum benefits to the community as a whole?

4. Evaluating Alternatives

What are the impacts and potential problems of the industrial wastes on the effluent, on the sludge, and on the environment?

5. Selecting Plan

Do we have satisfactory pretreatment standards and regulations?
Do these plans include adequate personnel and equipment to implement the regulations?
Are these plans adequately funded through a local revenue system?

Legal Authority

The municipal treatment agency operates a pretreatment program under local legal authority. This legal authority may take the form of statutes, ordinances, contracts, agreements, or other legal documents. It must be binding upon industrial users, enforceable under contract law or police powers, and at a minimum should allow the municipal plant to:

- Deny or place conditions on discharges
- Require compliance with pretreatment standards
- Require an industrial compliance schedule for required technologies
- Require industries to submit self-monitoring reports so that compliance can be assessed
- Conduct inspections, surveillance, and monitoring to determine compliance or non-compliance. Access to industrial records and entry to any industrial users' premises must also be allowed
- Independently assess or recover through judicial action: fines, penalties, or injunctive relief damages for non-compliance by the industrial users
- Immediately and effectively eliminate any discharge of pollutants to the municipal treatment plant which endanger the health and welfare of the community, and/or the proper operation of the facility.

Industrial Waste Ordinance

All of these requirements must be met before the pretreatment program can be approved. They can usually be met through the development of an industrial waste ordinance. No ordinance now exists that can be considered a truly typical ordinance. Each situation demands its own special features. However, existing ordinances may be modified to fit special needs. Ordinances, in general, may:

- Be self-contained (complete in itself with no separate documents required)
- Consist of simply stated general principles using separately published rules and regulations for enforcement
- Incorporate a permit system.

Smaller communities with few industries will often use a self-contained ordinance without permits. A general ordinance that is supplemented with rules, regulations, and permits is more flexible for larger cities.

Parts of an Industrial Waste Ordinance

General Provisions — includes purpose, policy, legislation and definitions

Regulations — includes prohibitive discharge standards, categorical standards, state requirements, excessive and/or accidental discharges, and any applicable local requirements and options

Fees and Charges — includes information applicable to administering a pretreatment program

Administration — includes reporting requirements, permits, monitoring, sampling, and required pretreatment facilities

Enforcement — includes provisions and responsibilities for accidental discharges, non-compliance situations, permit revoking, show-cause hearing, and legal actions

Penalties — includes civil penalities and fines

Legal Clauses — includes conditions and provisions for avoiding conflicts or establishing priorities with other laws

Effective Dates — includes calendar dates

Sample Sewer Connection Application Form

Sample Wastewater Discharge Permit

The development of an effective industrial waste ordinance is relatively simple if the boundaries of the wastewater management agency coincide with the boundaries of a political subdivision. However, if several political subdivisions are served the development can become complicated. The guidance and assistance of legal counsel are needed in either case.

Resources

The treatment agency must show sufficient resources (funds and personnel) to operate an effective program. User charges are required when construction grant funds are involved. There are various bulletins which help in estimating resources.

Pretreatment Program Personnel Requirements

Wastewater Flow (mgd)	*Number of Industrial Dischargers*	*Personnel Requirements*
5	small	2-4
	large	3-6
5-25	small	2-4
	large	4-8
25-50	small	4-6
	large	10-15
50	small	6-8
	large	10-15
100	large	50-100

Organizational Structure

The success of a pretreatment program depends on how it is developed and managed. Furthermore, as a condition for federal grants, the municipality must adopt a program that includes regular monitoring and enforcement of the national standards. For large treatment systems, a well-defined organizational structure having personnel with specialized training and qualifications may be necessary. This organization would have a separate industrial waste division with responsibilities for operating the industrial pretreatment program.

For small systems the workload imposed by the pretreatment program is considerably less than the activities of a large organization. Instead of an industrial waste division, the work can be handled within the existing organizational structure, or by supplemental contract services.

The Industrial Waste Survey and Management Procedures

The treatment agency is responsible for conducting an industrial waste survey on its system. This survey concerns the identification and classification of the industrial users.

The advisory group should help:

- **Identify the principal industrial users of the treatment system**
- **Gather information about the industrial processes that produce wastes, the quantity and characteristics of the waste produced, in-plant control procedures, and pretreatment operations.**

As a result of this survey, the treatment agency should develop an information system, and written procedures for enforcing federal and local effluent standards. Guidelines must be developed to:

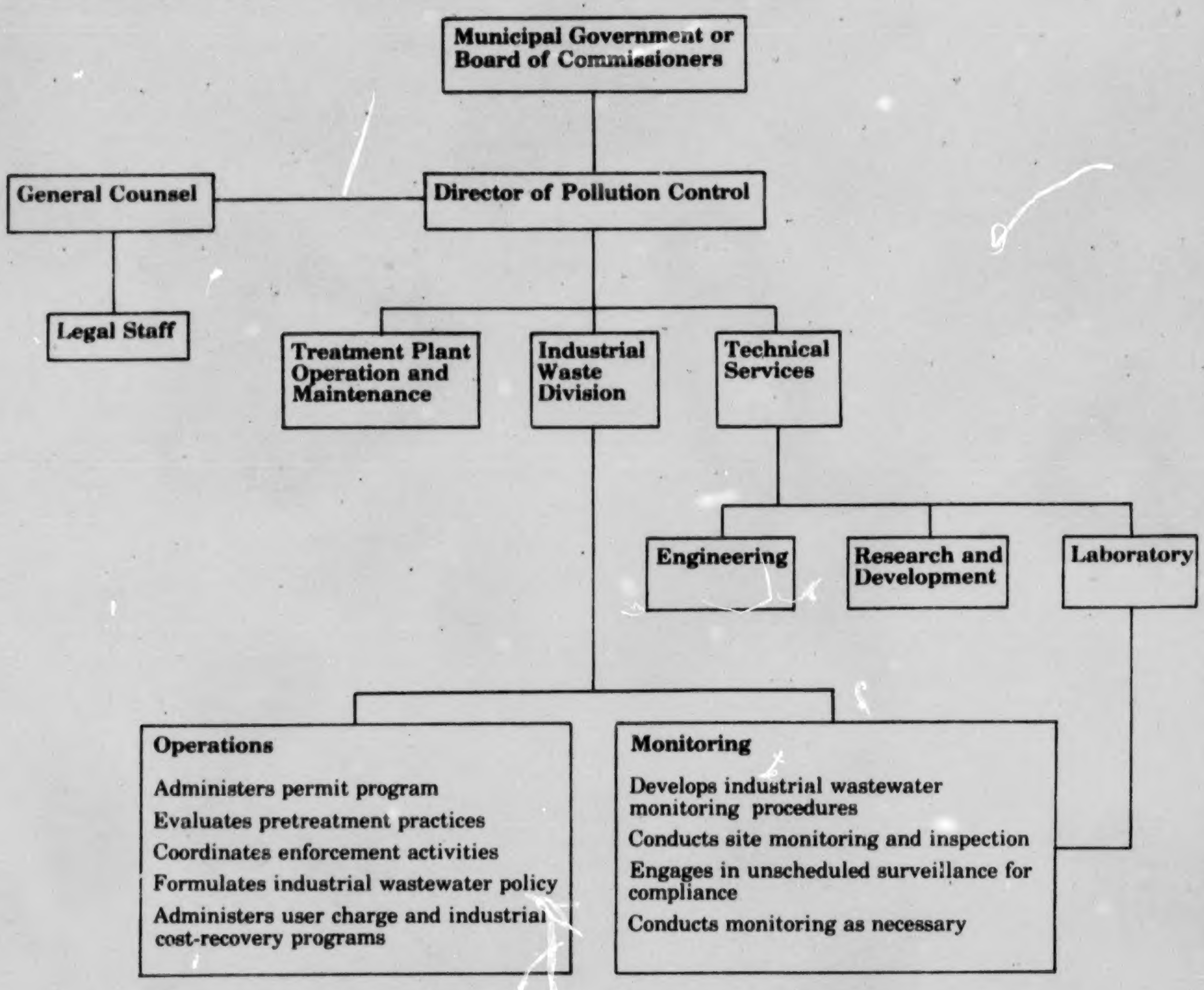
- Notify industrial users of specific categorical and prohibited discharge limits, including future requirements
- Analyze construction schedules of pretreatment works and self-monitoring reports submitted by the industrial users
- Respond to evidence of non-compliance by industrial users such as overdue reports and effluent violations
- Prepare an annual report of significant violations
- Set up a random sampling program to spot check the self-monitored reports.

The advisory group should be assured that the management procedures will provide the necessary information without adverse effects on the cooperation between industry and the community.

Revision of Categorical Standards

In some plants the treatment process may change a specific pollutant to a less harmful form. If the processes causing this alteration are not used generally in treatment plants, their effect may not have been considered in setting the nationwide categorical standard for this pollutant. In such a case, the treatment agency may apply for a revision of the categorical standard. This will allow more of the altered pollutant to be discharged, and reduce costs to industry with no environmental drawbacks. However, application and approval procedures for revised categorical standards are extremely stringent. They require extensive documentation, and are ineligible for federal funding.

Industrial Waste Enforcement Organization of a Large Municipal System


Municipal Government or Board of Commissioners
General Counsel
Director of Pollution Control
Legal Staff
Treatment Plant Operation and Maintenance
Industrial Waste Division
Technical Services
Engineering
Research and Development
Laboratory

Operations

- Administers permit program
- Evaluates pretreatment practices
- Coordinates enforcement activities
- Formulates industrial wastewater policy
- Administers user charge and industrial cost-recovery programs

Monitoring

- Develops industrial wastewater monitoring procedures
- Conducts site monitoring and inspection
- Engages in unscheduled surveillance for compliance
- Conducts monitoring as necessary

Variances from Categorical Standards

Categorical standards are set on an industry-wide basis. Specific industries may use a manufacturing process which is not considered in the development of a categorical pretreatment standard. In these cases where industrial processes are fundamentally different from other facilities, the categorical standards may be changed, thus making them more or less stringent than before. Any interested party, including the industrial user, may request a variance.

Approval of Pretreatment Program

After the pretreatment regulations are developed, they are transmitted to the proper regulatory agency for approval. The documents submitted must contain enough information to demonstrate the treatment agency's ability (financial, legal, and technical) to carry out the pretreatment program.

Enforcement

The treatment agency plays the major role in enforcing the compliance of pretreatment standards by industrial users. Where approved pretreatment programs exist, state and federal enforcement activities serve in a backup capacity.

The Clean Water Act, besides granting enforcement mechanisms and authority to the EPA and states authorized to issue NPDES permits, also *permits citizens to bring civil suits against the violators of pretreatment standards*. This consideration must be taken into account when developing a pretreatment program and during subsequent public notification.

The main vehicle for enforcing pretreatment programs is through the treatment agency's NPDES permit. Therefore, municipalities should:

- Develop sound pretreatment programs
- Enforce the requirements
- Give credit to industry for pollutant removal and sludge management.

Failure to enforce a pretreatment program in accordance with a permit schedule may preclude a municipality from receiving future construction grants.

Compliance

The state or the EPA develops compliance schedules as part of the NPDES permit. Completion dates for certain activities are based on construction grant award dates, pretreatment, and the industrial group to which the user belongs.

Regulatory limits on the time for developing a pretreatment program are:

- Approval of the program by the state or EPA within three years from the incorporation of a pretreatment compliance schedule in the municipal permit, or in accordance with the permit schedule and no later than July 1, 1983
- Approval of the program by the state or EPA by July 1, 1983
- Development of certain elements in the pretreatment program for the Step 2 (design) and Step 3 (construction) grant applications after December 31, 1980
- Approval by whatever more stringent time limit is imposed by the agency that issues the permit.

The treatment agency must develop procedures to insure compliance with the pretreatment program.

Summary

A publicly-owned treatment works should view the development and operation of a local pretreatment program as a chance to ensure reliability in operation of the wastewater treatment facility, and to provide a consistent and fair approach to local industry affected by General Pretreatment Regulations. The treatment agency should set as its goal the development of a sound pretreatment program with a firm commitment to enforcement.

Both the pretreatment program requirements and the industrial categorical standards are recent actions by EPA. In some areas they are still in the developmental stages. Changes in both areas are likely in the future.

The advisory group can help implement a satisfactory pretreatment program that controls toxic materials and other pollutants that are incompatible with wastewater treatment processes. Implementation of this program takes cooperation between industry and the agency. The public also must be involved.

The advisory group should evaluate the interests of the industrial users, the treatment agency, and the public as soon as facility planning begins. In this way the needs of all three groups can be built into the facility plan.

Industrial Pretreatment Ordinance

Grand Rapids, Michigan

Adapted from "Case History, City of Grand Rapids, Michigan. Program of Industrial Waste Control" by J. A. Breiner and H. H. Bouma. Pretreatment of Industrial Waste, Joint Municipal and Industrial Seminar, *U.S. Environmental Protection Agency, Seminar Handout, 1978. pp. 453-488.*

Grand Rapids, Michigan, is a city of 190,000 persons. Industry is highly diversified, and includes one of the largest concentrations of electroplating firms in the country. The Grand River which runs through the heart of the city is an important recreational resource for western Michigan.

Industrial Problem

During the late 1950's and 1960's industrial pollution of the Grand River created severe environmental problems, including periodic fish kills. As the environmental movement gained momentum during the mid 1960's, public attention in Grand Rapids was focused on the deteriorating state of the Grand River. In January of 1969, the Grand Rapids City Commission enacted the Comprehensive Water Pollution Control (Sewer Use) Ordinance, establishing effluent limitations for cyanide, heavy metals, as well as other provisions. Metal plating companies lobbied strenuously against any limitations, arguing that the cost of pretreatment would force them to relocate elsewhere. The quality of the water and the environment remained paramount, as the ordinance was adopted.

Ordinance Provisions

The city ordinance designates the management authority and legal authority necessary to implement and enforce sewage regulations. The ordinance subjects all users to the provisions, including a detailed definition of prohibited and restricted pollutants. Violations are designated as a public nuisance subject to penalty. The ordinance also permits the inspection of the sewer users' premises by properly authorized municipal employees.

Industrial Use Regulations

The regulations are divided into eight sections. R-1 specifies the inclusion of users in the industrial cost recovery system in which users are required to pay their share of construction costs. R-2 provides the authority to require the construction of a sampling manhole, if needed. R-3 designates the standard methods that are to be used for the analysis of effluent. R-4 calls for a grab sample as an acceptable sampling procedure for toxic wastes. R-5 establishes penalty charges. R-6 assigns responsibility for the construction, operation, and maintenance of pretreatment facilities. R-7 controls the disposal of septic tank wastes. R-8 requires the disposal of all residue sludges in properly licensed sites.

Enforcement Program

The effluent limitations stipulated in the Sewer Use Ordinance and accompanying regulations require significant changes in industrial waste disposal practices. At the time of enactment, the city recognized that compliance would be best achieved through cooperation between the city and local industry. Each company was granted a two-year variance to the ordinance. This allowed them to exceed effluent limitations, provided that the city felt that satisfactory progress was being made toward reaching the limitations. An additional six-month variance was given as a "shake down" period after which active enforcement began. The extension was granted due to the slower delivery of pumps, motors, and other electrical equipment needed to complete the pretreatment systems in every plant.

Compliance Procedure

Following the two and one-half year period, industries were subject to penalties for the violation of effluent limitations. A standard procedure was adopted by the city to ensure uniform processing of all violations.

Public Involvement

The news media played an important role in the enforcement program. During the two-year variance, the industrial progress reports made to the City Commission were given a great deal of attention by the press. Following the end of the variance period, the news media frequently publicized violations, resulting in great embarrassment to the industries involved. In fact, the negative publicity was more of a deterrent than were the monetary fines.

Surveillance Program

Industrial compliance with effluent limitations is insured by an effective surveillance program. It is set up as a full-time operation that is adequately staffed and equipped to conduct regular and routine effluent sampling in such a way that proper and reliable data results.

Collection and Disposal of Industrial Sludges

Sizeable quantities of both liquid and solid metallic sludges were generated once the pretreatment systems became operable. The creation of industrial sludges created a local demand for the transportation and disposal of these wastes. Disposal is under the jurisdiction of the Michigan Department of Natural Resources. Little attention was initially paid to disposal practices due to the lack of applicable legislation and experience.

Recently, however, with increased knowledge of sludge disposal, strict legislation was enacted and many sites were closed. At present, there is no licensed site in or near Grand Rapids for the disposal of industrial sludges. The cost for transporting and disposing of sludge has tripled or quadrupled as a result.

Effects of the Pretreatment Ordinance

Since the adoption of the pretreatment ordinance, there has been significant reduction in metals found in sewage influent and effluent.

Metal Concentrations

	Influent (mg/L)	*Effluent (mg/L)*
Before pretreatment	12-13	9-10
With pretreatment	2	1
Percent reduction	87	92

It appears that municipal treatment plants are capable of removing or treating low levels of metals, but efficiency decreases with increasing influent concentration.

Land application of sludge becomes more feasible in Grand Rapids as the metal content in sludges continues to decrease. The agricultural use of sludge could prove worthwhile both in resource recovery efforts and in reducing the costs of incineration.

Water Quality Improvement

By 1972 the flow of industrial wastes into the Grand River was slowed to a mere fraction of its former volume. In the spring of '72 the river was stocked with trout and salmon. Development of the fishing industry is only the beginning, and the future of the Grand River as a recreational resource is almost unlimited. Additional parks are being planned for development and many recreational activities are centered on or near the river. The public attitude toward the Grand River has been converted to one of appreciation and respect in just a few years. The situation continues to improve.

Need More Information?

Federal Guidelines, State and Local Pretreatment Programs. MCD-43, Vols. I, II, III. Washington, DC: U.S. Environmental Protection Agency, Office of Water Program Operations, 1977. 661 pp.

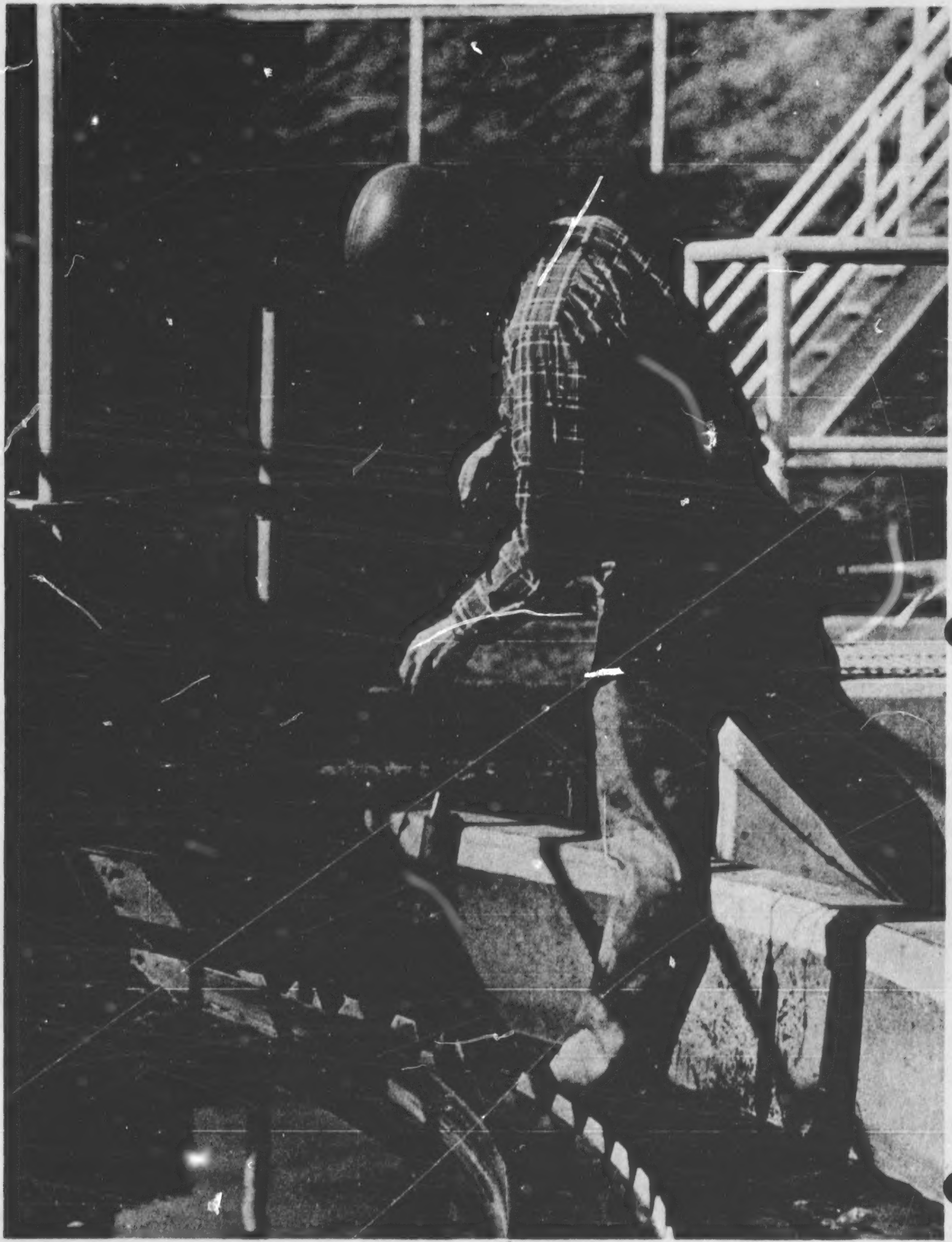
> This document contains the most detailed information available on pretreatment programs. However, it is being revised in 1980. Volume I describes the program. Volume II provides information on pollutant removal, pass through, and interference with the municipal treatment plant. Volume III contains information on the 24 industries for which categorical standards are being developed. This document is available from the General Services Administration, Centralized Mailing List Services, Building 41, Denver Federal Center, Denver, CO 80225. Be sure to mention the title of the publication and the MCD number when ordering.

Guidance for NPDES States on Implementation of the General Pretreatment Regulation (40 CFR, Part 403), 1979.

> This document may be procured from the Permits Division (EN-336), U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460.

Local Pretreatment Program Requirements and Guidance. Springfield, VA: Environmental Technology Consultants, Inc., September 1979. 135 pp.

> This document serves as the basis for the preparation of this handbook. It represents the viewpoints of the consultants, and the requirements to be met by wastewater treatment agencies in developing an approved local pretreatment program. It is the most up-to-date document on the subject. It contains detailed information on each of the subjects discussed in the handbook. It can be obtained from Environmental Technology Consultants, Inc., The Executive Plaza, Suite 502, 6501 Loisdale Court, Springfield, VA 22150.



Chapter 15

Wastewater Facilities Operation and Management

David A. Long

O & M—What is It?

O & M traditionally has meant "operation and maintenance" to people associated with water quality management and facility planning. A more appropriate meaning for O & M is "Operation and *Management*". Most of us are familiar with the need for O & M in daily living activities, including:

- Operating and managing a household with budgeting
- Operating and maintaining appliances and automobiles
- Painting and making repairs necessary to protect investments in physical structures, such as a house
- Engaging in health care activities such as annual medical and dental checkups.

All of these activities require proper management to achieve our goals in family living. Likewise, in order to achieve our goals in water quality management, we must make certain that O & M considerations at wastewater treatment facilities receive our earliest attention in the planning process.

The advisory group can assure that these matters receive the attention they deserve. The most perfectly designed system will not work if it is not maintained!

What Does O & M Cost?

Of course operation and management costs money, but in the long run it is a wise investment. Good O&M protects investments in expensive treatment plant equipment and structures.

Why are these fish dying or already dead? Just a few scant months ago the area was ideal for sport fishing. Who or what was responsible?

Yes, these fish were killed by the local municipal wastewater treatment plant.

The investigator's record reported . . . "Equipment malfunction." What really happened?

That's right. Poor operation and management of the treatment plant was the real killer, by allowing the discharge of a toxic effluent into waters where fishing formerly had been good. The cost to the community was a $15,000 fine plus the value of the fish . . . not to mention a degraded environment.

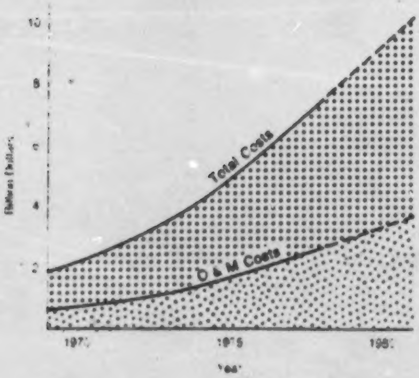
A similar situation occurred at a treatment plant that was hopelessly overloaded. It required an unbudgeted emergency expenditure of $35,000 to make corrections to equipment. What was the *real* cause of failure? This time city officials were blamed. They failed to enforce an existing sewer use ordinance.

By contrast, consider a well-run plant that removes 85 to 90 percent of suspended solids from wastewater, while undergoing a 25 percent overload at the same time! This accomplishment is achieved by well-trained, professional operators. Local officials and citizens must realize that the evidence at hand proves that *proper operation and management of a wastewater treatment facility are not extra cost items. Rather, they more than pay their own way!* We must never lose sight of the fact that properly trained professional wastewater treatment operators and technicians are key components in any water pollution control system!

Several years ago, the U.S. Environmental Protection Agency (EPA) engaged an independent business consulting firm to conduct a detailed survey of the measurable effects of operator training. Summing up the findings of the report, one of the authors made these observations:

- While the report is limited in scope, it clearly establishes the salutary effect of operator training on plant performance
- The public return on investment in this training is a little short of astounding As calculated for Texas plants, *for every dollar invested in training, the public has received $91 in measurable return.*

Local Expenditures for
Wastewater Collection and Treatment



The survey acknowledges that training probably increases the cost of operations and routine maintenance which are funded out of local funds. Therefore, by itself, training may not be an appealing investment to local decision makers. However, in light of the heavy fines for substandard, noncompliant plant operation, training which moves a plant into compliance will provide a sound investment.

The survey found, also, that the benefits of training were clearly obvious in maintaining consistently high performance at already successful wastewater treatment plants, as well as improving performance at the less successful, or substandard plants. At 19 Texas facilities, the removal of BOD and suspended solids improved in a range of 112 percent to 334 percent as a result of operator training.

It rapidly is becoming apparent to municipal, state, and other officials responsible for water pollution control that an improvement in operator efficiency will have one major, desirable effect – an upgrading and improvement in the overall quality of our waterways.

A plant properly operated and managed will pay off in prolonging the life of the facility, which should provide tremendous savings to the community.

Who Pays for O & M?

Who pays for O&M?

We do! Or at least the community does.

Congress has mandated that it is the local government's responsibility, not the federal government's, to keep a waste treatment facility operating. Once constructed, the facility belongs to the municipality. The EPA then has only a regulatory role through an effluent discharge permit system.

The costs of operating treatment plants are increasing rapidly as a result of higher treatment requirements and increased costs for energy and chemicals. The community is responsible for these operation and management costs.

O & M and the Law

The Federal Water Pollution Control Act of 1972 (PL 92-500) as amended by the Clean Water Act of 1977 (PL 95-217) addresses O & M in several sections.

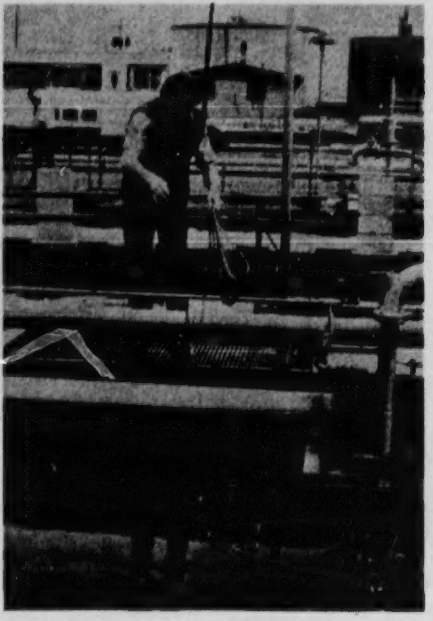
The awarding of a construction grant, as provided by Section 204, is conditioned upon the grantee's assurance that the new plant will be operated and maintained properly. Among the steps required under this Section are:

- Preparing a complete plan of operation, approved by the state water pollution control agency, which lays out a detailed schedule for timely action on adequate staffing, training, and budgeting to assure effective start up and continued operation of the facility
- Establishing a user charge system to provide adequate funding for annual O & M costs, including replacement.

The implementing regulations for the construction grants program contain requirements designed to assure proper O & M of treatment facilities constructed with grant funds.

Additionally, Section 210 of the Act requires that an annual survey be made and reported to Congress on the actual performance of federally-funded plants. These surveys indicate that one third of the plants inspected appear not to be meeting their design criteria for removal of BOD and suspended solids. Also the effluent from approximately one half of both new and existing treatment plants presently are not meeting satisfactory levels of secondary treatment.

At present, there is no requirement for an independent review of the operation and management elements of facility plans. However, EPA is considering such a "third party" review prior to facility plan approval. Additionally, the EPA has proposed that Step 1 (facility planning) plans be reviewed to determine whether or not a proposed new facility is really needed, or whether the existing facility or a modified version of it will accomplish the same water quality management objectives.



O & M Considerations in Planning

Proper planning for water quality management must address O & M very early on. Everyone must recognize that the total burden of paying the continuing costs of O & M rests solely on the residents to be served by the plant. *Early public involvement in facility planning can help to get this point across. Also, through effective public involvement, more citizens may come to view their wastewater treatment facilities as a resource and an asset to the community.* Community pride in a facility can lead to proper O & M.

The advisory group can see to it that the following are addressed in the planning process:

- **Survey and inventory of O & M problems in existing plants in the area**
- **Development of action plans and institutional arrangements to solve identified problems**
- **Development of good O & M plans for the new facility**
- **Study of ways to ensure continued attention to O & M**
- **Integration of small systems management with that of central facilities**

- **Contracts with firms which specialize in the operation of wastewater facilities to manage the local plant.**

Knowledge of local conditions can be very helpful.

Indicators of Good O & M

Many aspects of sewage treatment plant O & M are too technical for an untrained person to understand or even be aware of. However, there are some general indicators of good O & M practices which are apparent even to untrained observers.

The advisory group can form an initial impression of existing O & M practices to help guide the evaluation of O & M. Visit plants as a start!

On these visits persons can assess the attractiveness of the general environment, work conditions, and the appearance of surface waters below the plant discharge pipe.

Major O & M Challenges

The National Operational and Maintenance Cause-and-Effect Survey conducted by EPA shows that good performance of wastewater treatment plants is possible. The survey evaluated details on the system and unit process performances, operation and maintenance practices, and administrative procedures of O & M at existing treatment plants.

The following sections discuss some of the major factors found to cause poor plant performance.

Process Control Actions

Process control refers to those actions taken by an operator to adjust a treatment process in order to improve its efficiency. It is the leading cause of poor performance at a number of plants. This problem occurs when:

- A trained operator, in a well-designed plant, does not operate the plant as efficiently as possible
- The operator makes incorrect control adjustments or incorrect control test interpretations
- Poorly designed or inadequate parts of the treatment process are continued, instead of using different operations or modifying the plant for improved performance.

The lack of testing and control often was caused by the failure of operators to apply learned techniques. *Motivation by wastewater treatment plant supervisors is the key.*

Process Control Testing Procedures

Inadequate process control testing means that information needed for process monitoring and operation control either is wrong or not available. This deficiency leads to poor decisions. In many cases, important measurements which must be used to operate processes properly were not even made. *Good laboratories, personnel, and sampling equipment are necessary to gather adequate data on which to make operational decisions.*

Plant Performance

- What kind of performance record does the existing plant have?
- Is the plant achieving or exceeding the standards set by the design criteria?
- Is the plant being operated in the most energy efficient manner?

Process Control Monitoring

- Does the plant have its own laboratory?
- What kind of sampling and testing program exists?
- The NPDES permit system requires frequent self-testing and reporting; how is this requirement being met?
- What sources and types of wastes are treated by the plant?
- Does runoff from rain and snow melt leak into sewers?

Infiltration/Inflow

Infiltration/Inflow (I/I) refers to water which enters the sewers as a result of leakage of groundwater (infiltration) or rainwater (inflow) into the sewers. I/I was a major problem in a majority of the treatment plants included in the survey. The problem exists in the sewer collection system, but its effect on treatment plant operations cannot be ignored. Location of I/I sources and repair of the leaks is important!

Inadequate Understanding of Wastewater Treatment

This problem is defined as a lack of knowledge by the operational staff. A knowledge of wastewater treatment is needed if an operator is to do more than just keep the equipment operating. *Education and training is the key to efficient operations.*

The advisory group should ensure that needed education and training will be provided at the proper time.

Education and Training

- How large is the plant's staff?
- Does the plant have a full-time operator?
- Who actually hires plant personnel?
- What qualifications are required?
- Are operators certified by the state?
- How are employees trained for their jobs?
- Are opportunities for continuing training provided?
- What are the differences in staff salaries and skills needed by treatment plants?

Technical Guidance

In far too many instances, improper technical guidance has been provided to plant operational staffs from "authoritative" sources such as design engineers, state and federal regulatory agency personnel, equipment suppliers, and operator training staff. This factor may well be one of the most difficult to overcome because of the lack of people experienced in plant O & M. *The community must support the plants by hiring persons trained to interpret data and operate the equipment. Inadequately trained personnel cannot be expected to perform high quality tasks. Good people demand competitive salaries.*

Ease of Control and Adaptability

Plants vary as to the use of process control and ability to adapt to changing conditions. These factors are related to the plant design. They are extremely important considerations because changes in wastewater flows and waste characteristics require that changes be made in operation of the treatment units. *Facility planning must take into account the need for varying operation. Plans for handling toxic material spills and other emergencies also must be developed.*

Other Causes

Other causes of poor O & M performance include ineffective O & M instruction manuals, unsatisfactory maintenance programs, inadequate budgeting support for O & M, and improper facilities design and construction.

It is important to note that in all of the plants included in the cause-and-effect survey, *a combination of factors always limited performance. No single cause of poor performance at any one facility was ever observed.* There is a relationship between the reasons for poor performance and adjustments needed to improve O & M. Most existing programs for correcting poor performance focus on single problems only. Therefore, a new approach which addresses all problems at a particular facility is needed. This approach should be spelled out early in the facility planning process so that appropriate action can be taken at each step along the way.

All aspects of facility planning should be reviewed for O & M impacts. For example, multiple use programs can be of tremendous benefit to O & M. Besides stimulating better housekeeping and efficient operations, multiple use involvement builds a support base for O & M budgets.

The performance of wastewater treatment systems often may be improved simply and inexpensively by:

- **Upgrading operation and maintenance programs**
- **Giving more attention to management and administrative requirements**
- **Making low cost corrections of design deficiencies where they exist.**

Plans and Procedures

- **What type of maintenance system is in use? Is it a preventive system, or does it merely respond to breakdowns?**

- **What type of maintenance system is in use? Is it a preventive system, or does it merely respond to breakdowns?**

- **Is there an operation and maintenance manual written especially for the existing plant? Do the operators use it? Will there be one for the new plant?**
- **Who will set the yearly operation and maintenance budget for the plant? Is the money collected for water service and sewer use charges to be set aside to finance water quality activities, or will it be placed in the community's treasury for general use?**
- **Is there an emergency plan for spills of toxic materials, floods, loss of power, etc.?**

Summary

Better operation and management (O & M) means cleaner water, but attention to O & M pays off even more. It saves money, too! It protects the huge investment that a community makes when it builds a wastewater treatment plant by helping to get the most out of it.

Many existing wastewater treatment plants do not meet their design and permit requirements. EPA surveys show that the major problems with these plants were caused by O & M failures. The most common problems are:

- **Improper operation by inadequately trained operators**
- **Inadequate laboratory testing**
- **Inadequate general maintenance**
- **Temporary mechanical breakdowns.**

Unless a treatment plant is overloaded with more wastewater or stronger wastes than it is designed to handle, most problems can be solved by improving O & M performance.

Municipal officials and the public have three responsibilities for good operation and management of the treatment plant:

- ***Setting up a management system to establish proper control of collection and treatment systems***
- ***Providing well qualified, well trained, properly certified, and adequately compensated people at all levels to operate the system properly***
- ***Allotting sufficient funding to do the job.***

Mainly, good O & M boils down to recognition by the owners of the value of a good manager and good O & M personnel. They must recognize that these people are the most important link in good facilities performance.

The advisory group must see that these matters are addressed in the planning of the facility.

Case Study

Contract Management of O & M

Wausau, Wisconsin

Adapted from "The Wausau Connection: O & M Contract Helps Lift Sewer Moratorium." Reactor. Zimpro, Inc., February 1979. p. 13.

A private operations and maintenance contract has helped Wausau, Wisconsin, run off many consecutive months of effluent permit compliance, and resume sewer connections to newly annexed areas.

Repeated effluent violations during 1976 and 1977 had brought legal action against the city by the Wisconsin Department of Natural Resources. The Department of Natural Resources also had placed a moratorium on new connections to the Wausau sanitary sewer system, delaying the city's plans to expand residential and industrial development. Some $230,000 worth of sanitary sewer work had been frozen.

In April, 1978, Wausau signed a one-year, renewable supervisory O & M contract with a private contractor. Within 90 days, the plant began meeting its discharge permit limits of 30 milligrams per liter suspended solids and BOD. By December, the plant had run off six consecutive months of effluent compliance. As 1979 began, the Department of Natural Resources and the city of Wausau had settled the law suit and the sewer connection moratorium had been lifted.

Here's How They Did It

"We were having real problems at the plant," said Wausau Mayor John Kannenberg. "We've had to put money into plant improvements, but we're very pleased with the results of the private management contract. It's produced results." Achievements accomplished during this tenure include:

- The contract enabled existing plant operators to retain their positions. The contractor provided a plant manager, chief operator, and operator, and laboratory technician.
- A full plant preventive maintenance plan was instituted, and a card system was set up for inventory and spare parts.
- Training programs in plant operations, maintenance, and safety were undertaken.
- A system of monthly reports to the utility and regulatory agencies was initiated, and plant progress was reported regularly to the local media.
- Major items of equipment in need of repair or replacement were identified and reported.
- Defective sludge digesters were emptied, cleaned, and repaired. Major repair work on sewage influent pumps, comminutor, and grit removal equipment was completed.
- Primary and secondary clarifiers, and chlorine contact chambers were emptied and cleaned.
- Plant hiring procedures were examined. Three additional wastewater operator positions were defined, negotiated through the municipal personnel structure and local union, and eventually filled.
- A program of monitoring discharge from septic tank service trucks, and charging a users' fee was set up.
- The city and its consulting engineering firm drafted and began to enforce guidelines for industrial discharges into the sewer system.

Selected Resources

Need More Information?

Continuing Need for Improved Operations and Maintenance of Municipal Wastewater Treatment Plants. Report to Congress by the Comptroller General of the United States. CED-77-46. Washington, DC: U.S. General Accounting Office, April 11, 1977. 75 pp.

This report discusses the continuing need for improved operation and maintenance of municipal wastewater treatment plants constructed under grants awarded by the Environmental Protection Agency. Single copies may be ordered free of charge from Documents Handling, Box 6015, Gaithersburg, Maryland 20760. Specify order number CED-77-46.

Hill, William R., Regan Terry M. and Zickefoose, Charles S. "Operation and Maintenance of Water Pollution Control Facilities: A WPCF White Paper." *Water Pollution Control Federation Journal.* Vol. 51, no. 5. May 1979. pp. 899-906.

This article outlines the major problem areas affecting O & M as determined by a committee of the Water Pollution Control Federation. The paper also presents constructive recommendations for bringing O & M into compliance. There is a specific section which addresses the role that the owners and the public can play in this endeavor. Single copies may be ordered free of charge from the Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W., Washington, DC 20037.

Chapter 16

Urban Stormwater Runoff

Robert A. Simko

What Is Urban Stormwater Runoff?

Urban stormwater runoff is the water which flows off lawns, streets, paved areas, and rooftops during and after a rainstorm. This rain removes chemicals and suspended particles from the air. As it flows across the ground it gathers dust, debris, litter, animal refuse, and toxic substances. Although the environment often seems cleaner after a rainfall, in reality stormwater runoff merely carries pollution from one place to another. Unfortunately, what is washed from the streets, parking lots, and rooftops in an area may turn up in the water supply somewhere else.

What Are Nonpoint Source Pollutants?

Most people think of urban pollution as belching smokestacks, auto exhaust, and industrial waste—all of which originate from an identifiable source. Technically, these pollutants are identified as coming from *point sources*, places that literally can be pointed out.

Stormwater runoff, because it collects pollutants from a wide area, is called a *nonpoint source of pollution*. Though much less obvious than point sources, it can be equally as hazardous.

Toxic substances in stormwater include acid, dust, and coal particles from atmospheric fallout. Pollutants associated with automobiles include lead, asbestos, grease, rubber, and de-icing chemicals such as salt. Urban construction sites contribute sediment, plant debris, and asphalt. Stormwater also contains public refuse such as street litter.

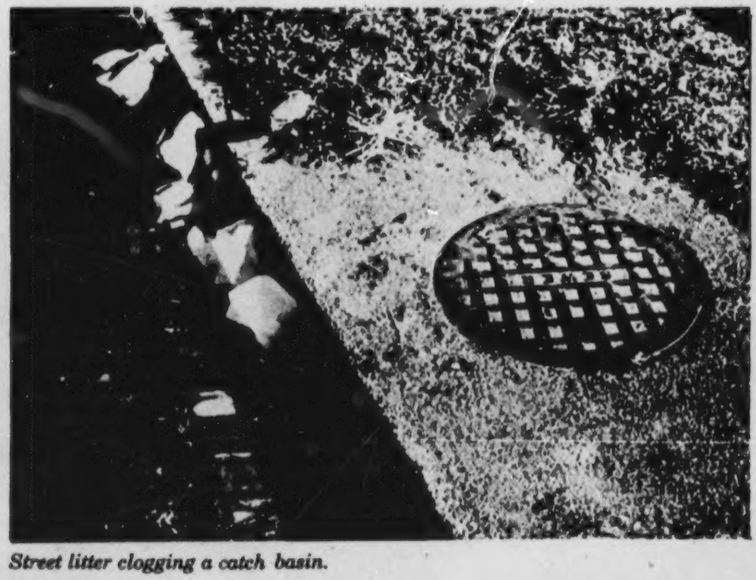
Origins of Urban Nonpoint Source Pollutants

Automotive Traffic
Heavy metals such as lead
Asbestos
Acid-making substances
Salts

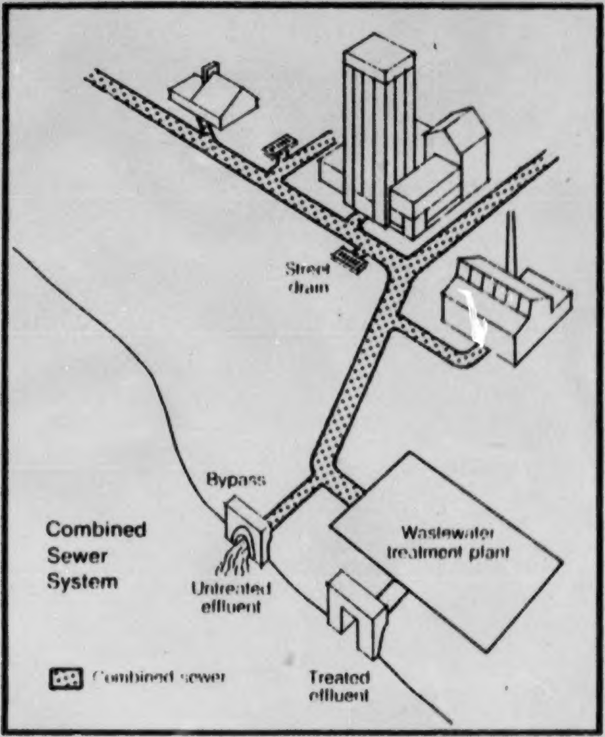
Construction Activities
Dirt
Asphalt and paint
Oil and cleaning solvents

Airborne Fallout
Smokestack debris
Coal dust
Acid-making substances
Dirt

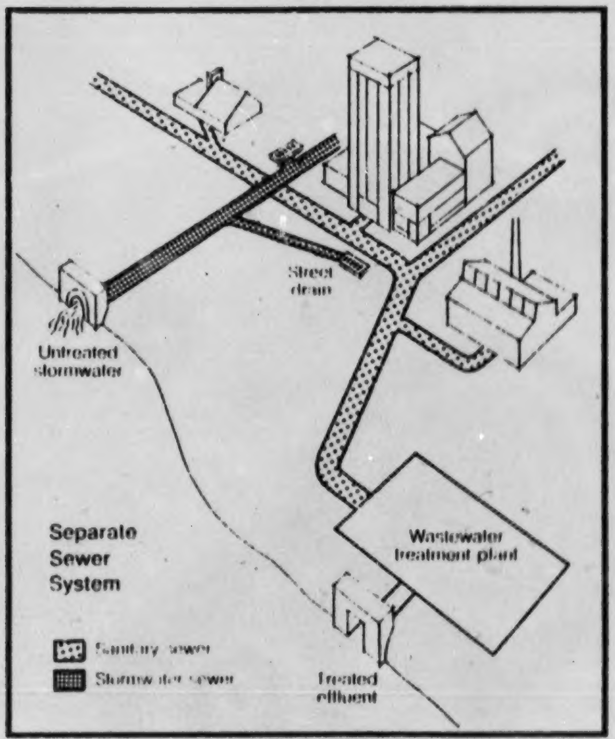
Public Refuse
Animal and plant refuse
Street debris
Trash



Street litter clogging a catch basin.


Street drain
Bypass
Combined Sewer System
Wastewater treatment plant
Untreated effluent
Combined sewer
Treated effluent

Transport of stormwater and wastewater together in combined sewers to treatment plant.


Street drain
Untreated stormwater
Separate Sewer System
Wastewater treatment plant
Sanitary sewer
Stormwater sewer
Treated effluent

Transport of stormwater and wastewater in sewers separately to surface waters and treatment plant.

How Are Urban Nonpoint Source Pollutants Transported?

Stormwater runoff is a major problem in many urban areas. This is because much of a city's land surface is covered by buildings and pavement. The pavement collects and channels the pollutant-laden stormwater, and directs it into the city's sewer system.

Urban stormwater enters either a combined sewer system which carries both municipal sewage and stormwater runoff, or a separate sewer which takes the stormwater directly to the nearest lake or stream. Combined sewers transport the stormwater to the treatment plant, possibly overload the plant, or bypass it to flow directly to the surface waters. Thus, it is not just stormwater that enters the lakes and rivers when there is a treatment plant overflow, but stormwater mixed with raw sewage.

How Serious Is The Problem?

In the past water quality planning was directed towards controlling point source pollution. Now, nonpoint source pollution is receiving increasing attention. It is a vital concern in water quality decisions for both urban and rural areas.

The full impacts of nonpoint source pollutants in urban areas are only now being assessed:

- The water quality of over 75 percent of urban areas studied by the Council on Environmental Quality were found to be *controlled* by nonpoint source pollutants
- Construction sites may have a sediment runoff rate 100 times greater than sedimentation from farmland
- According to the State of Illinois, nearly half of the pollution in the Chicago waterways is due to combined sewer overflows.

Urban stormwater runoff is of short duration, but it has far greater impacts than those of treated wastewaters. Over the same time period during a storm, urban runoff contributes much more heavy metals, suspended solids, and other substances to watercourses as compared to treated wastewaters.

Heavy storms which only last a short period of time (15 to 30 minutes) usually contribute the largest amounts of pollution. This is due to erosion and the dislodging of pollutant particles from surfaces.

Planning for Nonpoint Source Pollution

The concern about nonpoint pollution is growing. Section 208 of the Clean Water Act requires the control of nonpoint sources of pollution. State and local governments and areawide planning agencies are responsible for developing the control plans.

A six-step planning sequence is suggested for nonpoint source pollution prevention and abatement:

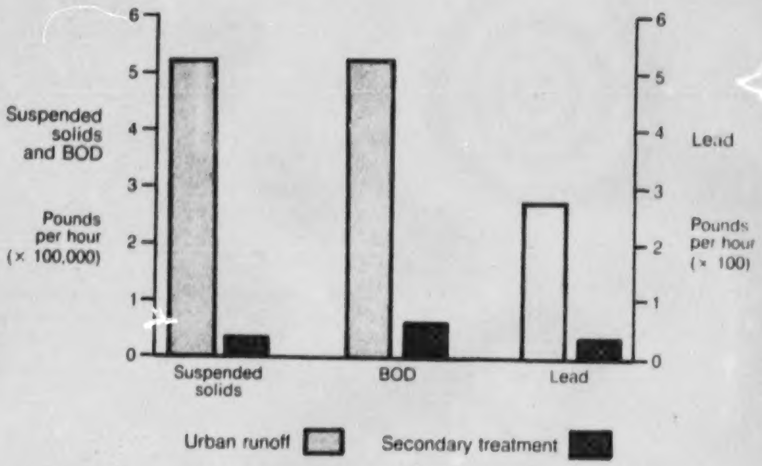
1. Set water quality goals and standards
2. Assess the local nonpoint source pollution situation
3. Determine allowable pollution loads for the various pollutant sources
4. Select Best Management Practices
5. Develop and implement a plan
6. Monitor the water quality and revise plans as necessary.

Step *one* establishes the basis for analysis and decision making.

States probably have already set water quality goals and standards, but advisory groups still have a role. Matters such as the scope of the studies and guidelines for considering possible tradeoffs have to be dealt with.

In step *two*, the sources, magnitude, and extent of nonpoint source pollution are assessed. The relationships between land use and the stormwater runoff are also determined. This step is difficult because it requires the collection of large amounts of data over an extended period of time.

Pollutant Loading during a Storm



Information on urban stormwater includes:

- Stormwater and surface water characteristics
- Environmental factors such as soils, slope, surface cover, and climate
- Pollutant types, amounts, and sources
- Demographic factors such as population and land use
- Existing and predicted urban stormwater problems, including those resulting from combined sewer overflow
- Ways to control stormwater pollution to meet the water quality standards
- Cost estimates for stormwater management plans.

Advisory groups can help identify the objectives of the studies, and give insights into local conditions. They also can assist in dialogue between the public and the technicians.

In step *three* allowable pollution loads are set. These requirements are based upon water quality standards, and characteristics of the pollutants and surface waters. This step is often bypassed in nonpoint source planning due to insufficient data.

Best Management Practices (BMPs), the techniques for preventing or controlling nonpoint source pollution, are identified in step *four*. Selection of the BMPs involves the consideration of regulations, reliability, fiscal aspects, technical matters, environmental impacts, and inter-agency coordination.

A *fifth* step in the process is the implementation of the plan. Although the plan is the responsibility of the agency, various private and public organizations participate.

The *sixth* and final step involves a constant monitoring of the plan. Changes should be made to meet future needs.

Input from advisory groups will be needed in the continuing planning process.

Advisory groups around the country are in various stages of planning. Most areawide 208 advisory groups are in the latter stages (Steps four to six). In contrast, many 201 advisory groups are just beginning the planning process. Central to all advisory group activities are the best management practices and plan implementation.

Best Management Practices

The options for dealing with problems of urban stormwater runoff range from doing nothing, to strategies for catching the stormwater runoff, storing it, and channeling it through treatment facilities. Doing nothing only neglects the problem until the waterways become open sewers. On the other hand, it would cost billions of dollars to separate the combined sewers, or build treatment plants large enough to handle all the stormwater that runs off city streets.

Best Management Practices

Structural Controls	**Nonstructural Controls**
Porous pavement	Open storage regulations
Parking lot ponding	Anti-litter laws
Infiltration systems	Air pollution abatement
Diversion structures	Catch basin cleaning
Vegetation seeding and mulching	Improved de-icing methods
Rooftop ponding	Public education
Detention basins	Street cleaning
Grade stabilization	Land use ordinances

Other management alternatives are available. They can be classified as structural or nonstructural measures. The structural ones involve the construction of physical works such as catch basins and dams. These Best Management Practices (BMPs) are relatively expensive.

Nonstructural alternatives often are more effective and less costly than structural measures. In addition to erosion and flood control benefits, they result in cleaner neighborhoods and environmental amenities. These approaches range from improved urban maintenance programs, to land use controls such as zoning to keep pollution-prone firms away from watercourses. Some of these nonstructural BMPs include:

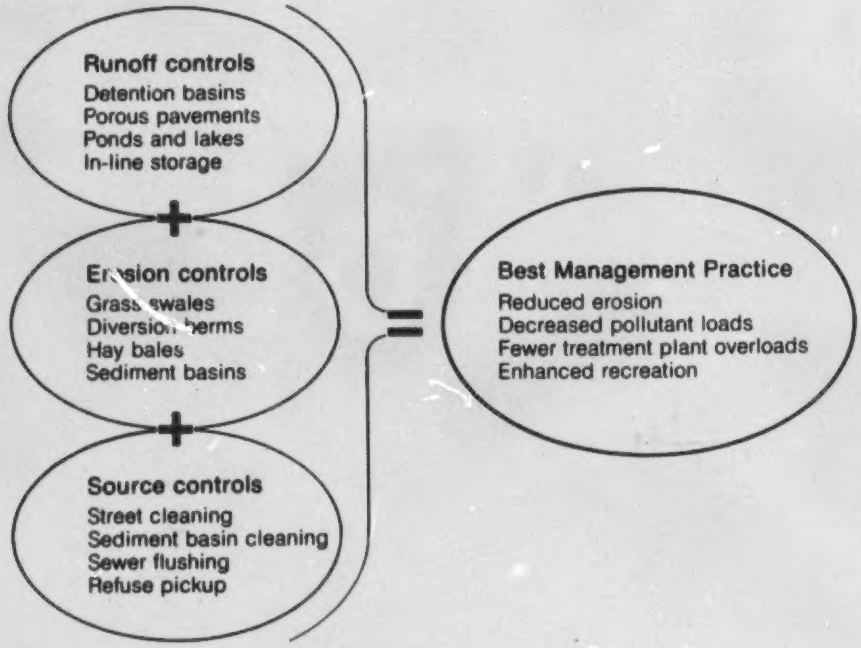
- Anti-litter ordinances and educational programs
- Erosion controls in building codes and subdivision regulations
- Frequent trash removal and street cleaning
- Cleaning of catch basins and sewer pipes
- Controls on herbicide and pesticide usage.

Strict enforcement of regulations is crucial. For example, effective street sweeping is seriously impeded by parked cars, because most of the street dirt lies within six inches of the curb. The public often does not realize the importance of such measures.

Because of the variability in pollution sources and physical factors such as climate, soils, and topography, *no one best management practice will fit all situations*. BMPs must be tailored to fit the needs of particular sources, and circumstances. In urban areas, BMPs are often directed towards three aspects of urban nonpoint source pollution: erosion, pollutant sources, and stormwater runoff.

At the 208 areawide planning level the advisory group is concerned with assessing which alternatives can be implemented.

For example, where there is strong county or regional government, land use ordinances may be very effective in controlling nonpoint sources of pollution.


Runoff controls
Detention basins
Porous pavements
Ponds and lakes
In-line storage
+
Erosion controls
Grass swales
Diversion berms
Hay bales
Sediment basins
+
Source controls
Street cleaning
Sediment basin cleaning
Sewer flushing
Refuse pickup
=
Best Management Practice
Reduced erosion
Decreased pollutant loads
Fewer treatment plant overloads
Enhanced recreation

Best Management Practice is a sum of management techniques.

Advisory groups involved with 201 local facilities planning should be concerned with the implementation of nonpoint source pollution BMPs for two major reasons:

- **Assurance that local government actions are compatible with the areawide plans**
- **Influence upon the design requirements for wastewater treatment facilities and/or programs.**

Much information is known about urban stormwater, but a better understanding of pollution sources and control techniques is needed. The United States Environmental Protection Agency (EPA) has initiated the Nationwide Urban Runoff Program (NURP) to provide some of the answers. The main objective of this program is to develop improved solutions to runoff problems in various climates. Thirty extensive studies are being conducted under this program.

A Durham, New Hampshire study measures the loading of urban runoff constituents during individual storm events, and evaluates maintenance practices such as litter control, chemical-use control, street sweeping, and detention basins.

A project of the Council of Governments in Lane, Oregon, focuses on special concerns such as toxic materials and air quality-runoff interactions, management practices, and promotion of public awareness and actions.

Preliminary results of all the studies will be available when the NURP compiles its findings in a report to Congress in 1983.

Construction Activities

Construction is a major source of urban stormwater pollution. About a million acres of land are disturbed by construction each year in the United States. Sediment is the most common pollutant, but other substances are washed from the construction sites. These pollutants include asphalt, paint, cleaning solvents, and concrete compounds.

BMPs for construction activities fall into two groups: controls for erosion, and controls for chemicals and other substances. Some principles for managing soil erosion are:

- Keeping barren soils exposed for a minimum time period
- Preserving as much natural cover, topography, and drainage as possible
- Protecting fragile and erosion-prone areas from construction activities

- Prohibiting ground-disturbing activities during heavy rainfall
- Requiring stringent erosion prevention and control practices.

Despite the most effective BMPs, some erosion will always occur. Sedimentation can be controlled effectively by basins which trap runoff and allow sediment to settle out before the water leaves the site. For many construction projects these basins should be permanent.

Certain chemicals, pesticides, and fertilizers are also construction pollutants. They should be prevented from entering the water through proper storage and use.

Selection of Best Management Practices

Advisory groups have an important role in helping identify BMPs that are most suitable for the community. A few approaches that may be pursued include:

- **Contacting experienced municipal employees and labor unions (who may have to implement BMPs) for their insights**
- **Checking the compatibility of local actions and regulations with those of neighboring communities**
- **Reviewing existing ordinances to construction and other sources of nonpoint source pollution**
- **Explaining and publicizing the relationships between water quality and ordinances to the public.**

Regulatory vs. Voluntary Control Programs

The effectiveness of *voluntary* versus *regulatory* approaches to nonpoint source controls is a continuing controversy. Many programs, such as erosion and sedimentation abatement, initially have been voluntary. However, in an increasingly urban society the regulatory programs may work better than voluntary ones. Of course, voluntary programs could be more effective if incentives were present and residents had pride in their cities.

Voluntary Programs

Voluntary programs for the control of nonpoint sources of pollution should have the following dimensions:

- Leadership by organizations such as the soil conservation agency at the state level, and the council of governments at the local level
- Strong education and information program through the state extension service, agencies, and private groups
- Technical and cost-sharing assistance necessary to meet target abatement dates
- Programs to check progress and to evaluate periodically the work effectiveness.

Regulatory Programs

If a regulatory program is required to meet water quality objectives, a joint effort by state agencies, local jurisdictions, and other agencies may be needed. Effective regulatory programs often have these elements:

- Enactment of state laws which provide water quality standards and appropriate management agencies
- State soil conservation or municipal assistance agency for preparing model ordinances and regulations, and assisting counties and municipalities in local program development
- Local authorities for designating BMPs, approving construction site plans, requiring building permits, and enforcing building codes
- Arrangements for funding administrative and technical assistance costs, and monetary incentives
- Vigorous information and education programs.

Advisory groups, of course, cannot execute such actions. However, they can influence decision-making organizations, and act as an ombudsman between the organizations and the public.

Management Agencies

Several agencies have important roles in the control of stormwater pollution. The police department should enforce an anti-litter ordinance as well as parking regulations to keep curbs clear and allow street sweeping equipment to work more effectively. The highway maintenance department should clean the sewers. The town council should adopt a comprehensive plan with zoning regulations to protect fragile environments and unstable soils. The conservation district should supervise erosion and sedimentation control programs. The Soil Conservation Service should provide technical advice.

If the program is to be effective, all agencies must understand their own responsibilities and work together. Cooperation is more likely to occur if a formal, written agreement is made among the agencies which will be working together.

Questions to Keep in Mind

Advisory groups should keep the following questions in mind when advising agencies on alternative solutions to urban stormwater runoff pollution:

- **How much will it cost and how can it be paid for? What are the public and private costs (including capital, operation, and maintenance)?**
- **How effective is it in controlling water pollution? To what extent are pollutant loads reduced?**
- **How easy will it be to implement? What legal authority, financial resources, and administrative abilities are needed to carry out each option?**
- **What water resources, land resources, and cultural resources are affected?**
- **Is public health affected?**
- **What other important impacts will it have?**

Brief Recap

Urban stormwater runoff is a problem not only because of its scope and the large number and amounts of pollutants involved, but also because of the associated economic, social, institutional, and political issues which are difficult to resolve. Some of the more important issues are the cost and effectiveness of nonpoint source controls; the apparent need for more regulatory, as opposed to voluntary, control programs; and complications in water law.

Nonpoint source problems are variable, widespread, and serious. Planning for the control of such pollutants has lagged behind point source efforts, but substantial commitments are being made.

Controls and methods exist which reduce the nutrient, pesticide, sediment, and bacteria levels in urban stormwater runoff. The EPA, however, currently lacks detailed information on the BMPs used in a specific situation with the resultant improvement in water quality. More studies of these relationships are needed. Projects in the National Urban Runoff Program are compiling such information.

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Case Study

Developer Fees Pay for Stormwater Facilities

Weber and Davis Counties, Utah

The areawide water quality planning program for the tri-county area of Weber River Water Quality Planning Council started in June, 1975. A major effort of the Council was directed toward documenting stormwater facilities, identifying water quality related problems, and developing a master plan to correct these problems. This urban stormwater runoff study focused on the rapidly growing Utah counties of Weber and Davis.

Best Management Practices

Several alternative control methods were considered to alleviate flooding caused by urban stormwater runoff. The study concluded that a combination of large, central detention basins and smaller, onsite detention basins for individual developments was the most effective means. The construction of storm drains for peak flow was rejected because of the cost of installing the large diameter pipe needed to accommodate the high peak flow from the cloudbursts common to the area.

The study also examined alternatives to control or reduce the pollutant load that would accompany summer storms. Physical treatment processes were judged to be the most effective, but they were also the most expensive. Since no stormwater collection system or combined sewers are in use in Davis and Weber Counties, this alternative was rejected in favor of the detention basins.

Because a large fraction of the total pollution load is carried during the early stages of runoff, *it is important to design detention basins that will have all runoff detained for a period of time.* This measure allows for the reduction of the pollutant load by settling, rather than using the more conventional detention basins which accept runoff only during the peak flow.

Implementation

For Davis County, where all sixteen municipalities have implemented the master plan, the county government was selected as the management agency. The creation of a new and separate agency was considered, but it was rejected because it would not have authority for land use planning, developmental regulations, or the broad powers of county government.

The Davis County Commissioners have:

- established a committee to set drainage project priorities for the county
- adopted a stormwater runoff control ordinance for new development.

This ordinance enables the county to assess a fee for any additional stormwater facilities that are needed due to development. The fee is seven percent of the fair market value of the improved real estate. This was a major step in improving water quality in Davis County.

Detention basin with riser pipe.

Case Study

Pollution Source Analysis in Planning

Central Piedmont, North Carolina

The planning area of the Triangle J Council of Governments (TJCOG) consists of 1,750 square miles in the central Piedmont section of North Carolina. Sixty-eight percent of the region's population is contained in three major urban centers (Raleigh, Durham, Chapel Hill). The surrounding area is predominantly rural. In 1974, 22 communities participated in the water quality planning process.

Data Collection and Analyses

One of the major elements in this program was an in-depth study of nonpoint source pollution in the region. The approach used was a comprehensive pollution source analysis. Existing and projected water quality were assessed. The source, duration, magnitude, and extent of nonpoint sources specific to the planning area where identified. This was the first such study conducted under Section 208 grants.

The program also served as a demonstration effort to determine the feasibility of characterizing nonpoint source pollution as it relates to land use. This 12-month program also used computer models, which have now been modified to serve as water quality planning and evaluation tools. The cost for this effort was $400,000.

The results of this program showed that nonpoint source pollution potential was closely related to density of development. Four primary land use categories were found to represent potential nonpoint source pollution.

Pollutant Loading Rates Based on Model Predictions

Land Use	Pollutant Loading Rates (lbs/acre/day)			
	BOD	*Suspended Solids*	*Total Nitrogen*	*Total Phosphorus*
Urban	0.42	11.6	.027	.008
Commercial	0.29	21.5	.026	.010
Residential	0.17	18.5	.016	.004
Rural	0.12	15.0	.008	.003

The study also found that despite the high level of sampling and monitoring, some nonpoint source problems cannot be adequately documented. Pesticides, for example, were not modeled because of the large number of different chemicals used, and the expense of sampling and analysis for this parameter.

Best Management Practices

The TJCOG study also reviewed a wide range of best management practices (BMPs). Each was assessed on the basis of effectiveness in reducing nonpoint source pollutant loads which had been identified as problems by the sampling and modeling effort. Each BMP was analyzed in terms of its usefulness in reducing stormwater runoff and suspended solids levels, as well as its cost and effectiveness.

The least costly and most effective techniques controlled the pollutants at their sources. These options were much better than collecting and treating wastewaters containing the pollutants. Although the nonpoint source assessment concluded that the control of sediment was of primary importance, other nonpoint sources of pollution were identified.

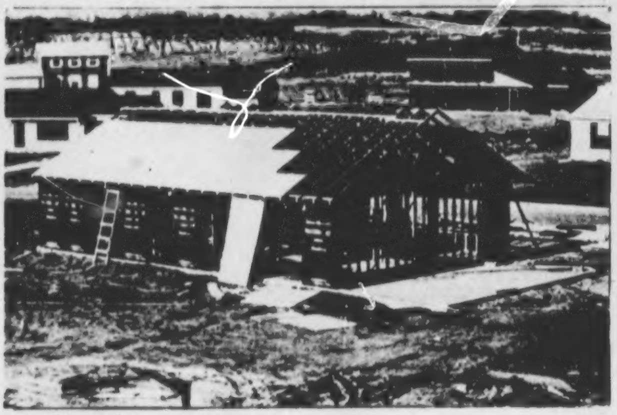
Implementation

The implementation of nonpoint source BMPs focused on correcting problems through existing institutional and legislative authorities and strengthening those authorities where possible, rather than attempting to control all potential sources.

Immediate controls were recommended for implementation if they were practical and inexpensive. Improved water quality could be expected by instituting better street sweeping, passage of local ordinances, and the employment of construction site inspectors.

TJCOG's sedimentation and erosion control program includes erosion control during all phases of construction. Better land management of construction sites is necessary to reduce suspended solids and associated pollutants, such as phosphorus and lead.

In order to control suspended solids, local governments have indicated they will consider requiring erosion and sedimentation control plans. Annual administrative costs for this approach will range from under $1,000 for small towns to over $65,000 for a countrywide program.



Residential construction site.

Street sweeper.

Need More Information?

Amy, Gary, et al., *Water Quality Management Planning for Urban Runoff,* Report No. EPA-440/9-75-004, Washington, DC: U.S. Environmental Protection Agency, December 1974. 247 pp.

> This manual describes procedures for quantifying nonpoint source problems in an area without the need of extensive data. It can be useful in assisting planners in the preliminary evaluation of cost-effective abatement and control practices. This publication is available as Order #0993A from the EPA Library Services, Maildrop 35, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

The Hidden Dangers of Urban Stormwater, Washington, DC: Office of Water Program Operations, U.S. Environmental Protection Agency. 10 pp.

> An easy-to-read introduction to the basic problems of urban stormwater runoff. Should be one of the first resources consulted. Available as Order #5734 from EPA Library Services, Maildrop 35, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

Setting the Course for Clean Water, Washington, DC: National Wildlife Federation, March 1978, 64 pp.

> Subtitled "A Citizen's Guide to the Section 208 Water Quality Management Program," this handbook is must reading for those citizens who want to participate in the 208 program. Copies are available at $2 each from the Education Division of the National Wildlife Federation, 1412 16th St., N.W., Washington, DC 20036.

Water Quality Management: Compendium I, Report No. EPA-440/3-77-026, Washington DC: Water Planning Division, U.S. Environmental Protection Agency, December 1977. 117 pp.

> Presents 58 successful case studies of water quality management planning agencies that are implementing 208 programs. The activities and solutions of these agencies are documented. Available as Order #4567 from EPA Library Services, Maildrop 35, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

Chapter 17

Nonpoint Source Pollution: Agriculture, Forestry and Mining

E. Drannon Buskirk, Jr.

The Problem

Of course you have noticed how refreshing the air is after a rainstorm. Did you ever wonder what happened to the air pollutants removed by the falling rain?

After joining other debris on the ground the pollutants flow into the sewers, lakes, and streams. Such substances of widespread origin which run off, wash off, or seep through the ground are called *nonpoint* source pollutants. Common nonpoint source pollutants include soils eroded from farms and construction sites, metals and oils removed from roads, fertilizers and pesticides washed off croplands, and acids leached from mines. Pollutants coming from distinct locations such as pipes are called *point* source pollutants. The impacts of many nonpoint source pollutants are only now being realized:

- Without controlling nonpoint source pollution the 1983 national goal of fishable and swimmable waters cannot be achieved in parts of at least 37 states.
- Two-thirds of the areawide water quality planning agencies identify nonpoint source pollutants as the main cause of their water quality problems.

Nonpoint source pollutants have many origins, including agriculture, construction, mining, septic systems, silviculture (forestry), and urban activities. Here we focus upon the major sources of the rural areas — agriculture, forestry, and mining.

Nonpoint Source Pollutants

Type	*Source*
Sediment	Construction sites Mining exploration and operations Croplands Logging roads and trails
Nutrients (e.g., fertilizers, grease, organic matter)	Croplands and livestock pens Gardens, lawns, and forests Petroleum storage areas Landfills
Acids, Salts	Irrigation fields Mines Roads and parking lots Landfills
Heavy Metals (e.g., lead, zinc)	Mining operations Vehicle emissions Landfills
Toxic Chemicals (e.g., pesticides, herbicides, fungicides)	Croplands Waste from building sites Forests Landfills
Pathogens	Domestic sewage Livestock wastes Landfills
Heat	Denuded streambanks

Planning For Nonpoint Source Pollution

Although most of the nation's water clean-up efforts have been directed at pollution from point sources, the concern for nonpoint source pollution is increasing. Section 208 of The Clean Water Act requires the control of nonpoint sources of pollution. The 1977 amendments to the Act further emphasize the role of nonpoint control programs. Since climate, land characteristics, and even the types of pollutants vary throughout the country, state and local governments and 208 planning agencies were given the responsibility to develop nonpoint source pollution control plans.

A six-step planning sequence is suggested for nonpoint source prevention and abatement:

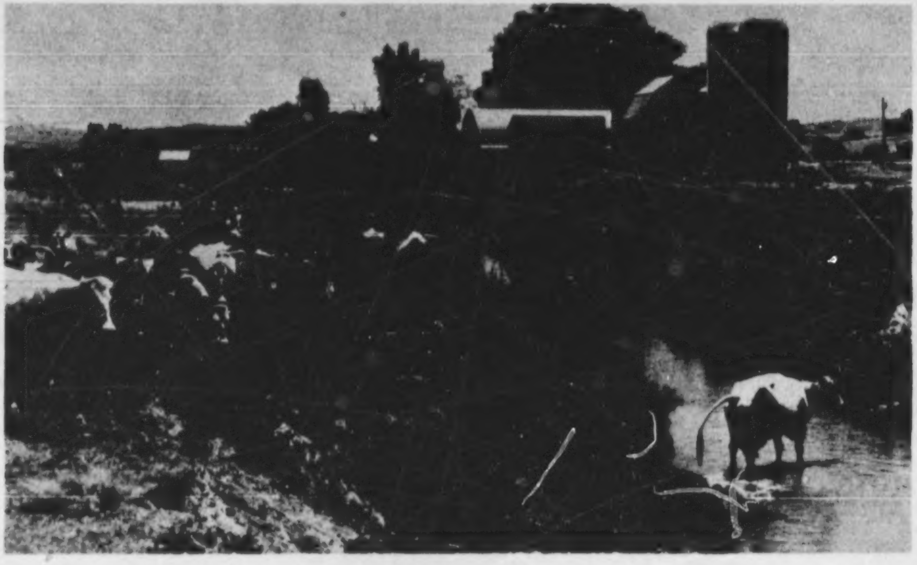
1. Set water quality goals, criteria, and standards
2. Assess pollution relationships
3. Determine allowable pollutant loads
4. Select Best Management Practices
5. Develop and implement a management plan
6. Revise plan and conduct ongoing planning.

Information Necessary for Decision Making

- Quality and location of ground and surface waters
- Climate variations, including volume, intensity, and duration of precipitation
- Land and soil characteristics
- Landforms, including slope and topography
- Vegetative cover
- Location of waste-producing and storage areas
- Cropping, logging, mining, and ranching methods
- Management of fertilizers, herbicides, pesticides, and fire retardant chemicals
- Existing, previous, and future land uses.

Before - Hillside eroded and worn out by farming.

After - Revegetated hillside after only three years.



Nutrient and sediment pollution caused by farm animals.

Set Goals, Criteria, and Standards

In step one the basis for analysis and decision-making is established.

Although states may have already set water criteria and standards, advisory groups have much to consider such as the scope of water quality plans and guidelines for making tradeoffs.

It is important that the total environment is kept in mind in water quality planning. Areawide and community benefits and costs, rather than just private gains and losses, should be considered. Most 208 planning groups have progressed beyond this point.

Assess Pollution Relationships

In step two the local nonpoint source situation is assessed. The quantitative aspects of pollution are determined.

Consultants or a technical staff must perform many of the tasks, but advisory groups can contribute by:

- **Helping to identify analysis objectives**
- **Questioning the analysis program to ensure that local needs are being met**
- **Giving insights into local conditions**
- **Communicating the questions of the public, and the findings of the technicians.**

Assessing and predicting nonpoint source pollution has had mixed success. The basic problems are inadequate data and a lack of knowledge about the dynamics of many pollutants. Too little data is collected during wet weather conditions. Massive data inputs such as hourly rainfall patterns for thirty years may be required. Computational procedures range from hand-calculation approaches to computer models.

Data collection is a complex matter. If it does not exist, it will have to be collected. Advisory groups will have to support the necessary time and expense. Furthermore, such matters must not be automatically left to the analysts and technicians. Their methods and findings must be continually questioned. For example, a sediment control ordinance is central to the nonpoint source pollution plan in Lewis and Clark County, Montana. Such an ordinance should require a single technique for computing storm water runoff throughout the watershed. Different computational approaches can give vastly different estimates of runoff volumes. Various kinds and sizes of control structures are based on these calculations. As a result, costs can vary greatly because of different calculations. For similar reasons, a common storm event such as a five-year frequency storm should be used in design work throughout the area.

Determine Allowable Pollutant Loads

Streams can handle only limited amounts of various pollutants. Therefore, to maintain water quality the total amount of a substance (load) entering a body of water over a period of time must be controlled.

It is not always possible to use load analysis. However, when it is done the advisory groups should fully understand how the allowable pollutant loads are determined. Such calculations can markedly affect an area's developmental pattern, such as the type, scale, and location of industries.

Select Best Management Practices

Next is the identification of the Best Management Practices (BMPs) — the techniques for preventing or controlling nonpoint source pollution. Selection of the BMPs involves the consideration of regulations, reliability, fiscal aspects, technical matters, environmental impacts, and interagency coordination.

Develop, Implement, and Revise Plans

In the final steps plans are developed, implemented, and revised. These latter planning steps have many opportunities for citizen involvement, especially the selection of BMPs and plan implementation. The constraints of implementation have a strong bearing upon the choice of BMPs.

Nonpoint Source Plan Implementation

Considering the breadth of nonpoint source problems, and the large number of governmental agencies that must cooperate to solve them, it is not surprising that the control of nonpoint source pollution lags. The initial focus in water quality management was on point sources. The first designated planning groups were those in metropolitan areas where point sources of pollution were most obvious. As a result, facilities planning and construction often preceded comprehensive areawide planning. Later, when states began 208 planning, nonpoint source problems received more attention.

As planners gained experience with nonpoint source pollutants, perspectives changed. Nonpoint source pollution in its principal mode of transport — storm water — was underscored in the 1974 annual report of the Council on Environmental Quality, which states:

> **Until the storm water situation is analyzed and efficient corrective measures taken, there is little or no sense in seeking higher levels of treatment efficiency in existing secondary plants.**

Although this statement is generally true, advanced waste treatment may be needed in some cases to meet water quality standards.

Areawide 208 programs are planned by state or regional units of water quality planning agencies. Nonpoint source controls for citizens, however, are administered by existing governmental institutions such as the United States Department of Interior, state environmental protection and natural resource agencies, and local conservation districts. Their effectiveness depends upon public acceptance, adequate laws, effective regulations, and sufficient resources for administration, monitoring, and planning.

In implementing water quality plans, citizens must be concerned about:

- **How pollution control programs are designed**
- **Who should be responsible for the control facilities**
- **How enforcement can be handled**
- **How to finance the program.**

Program Responsibilities

Control programs typically involve both private individuals and the government. Private citizens are expected to prevent nonpoint source pollution from their own properties. The public institutions have a broader set of functions, including:

- Jurisdiction where pollution crosses several governmental boundaries
- Review of control plans
- Inspection of construction and maintenance of facilities
- Enforcement of control practices
- Monitoring of water quality.

At least one county in Pennsylvania advocates that municipalities maintain responsibility for permanent erosion and sedimentation control facilities. This position is taken out of concern for facilities that fall into disrepair as the original owners die or go into bankruptcy.

Program Management

Planning would be best for an entire watershed, of course, but this option is seldom politically feasible. While much nonpoint source planning is done at the areawide level, it appears that plans can be effectively coordinated at the county level. Plan reviews and inspections should be handled by the local government. Unfortunately, few communities have the resources or staff for these duties. Several alternatives for plan reviews and inspection activities exist:

- Township engineer (fees paid by several municipalities)
- Conservation district
- Code enforcement agency or council of governments
- Joint watershed authority.

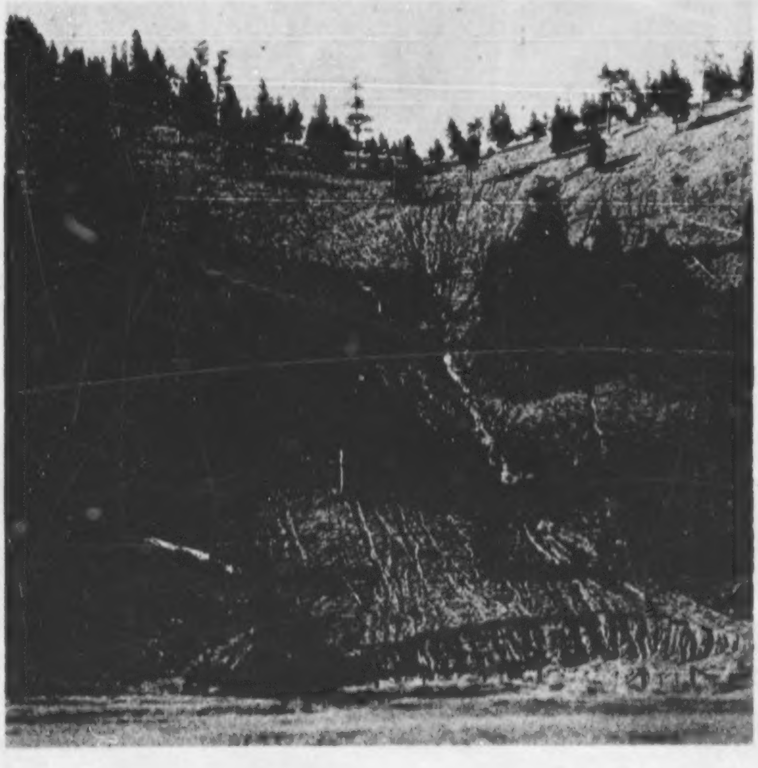
In addition to these kinds of arrangements, advisory groups need to examine existing opportunities for controlling of nonpoint source pollution. Such opportunities include:

- Land use controls such as zoning
- Building codes such as road width requirements
- Subdivision plan reviews
- Water and sewer permits
- Regulations such as refuse disposal.

Of course, neighboring municipalities may have incompatible controls such as conflicting land use ordinances. These problems are to be expected. Nonpoint source planning is a continuing process. Rarely will all the desirable arrangements be present.

Governmental nonpoint source controls are based upon two types of policies: incentives and regulations. Different approaches are favored by the various agencies, or are required by law.

Erosion caused by a single rainstorm on overgrazed range land.



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Agriculture

The agricultural community believes that pollution control can be done through various non-regulatory means. Several governmental agencies and programs follow such policies in providing financial and technical services:

- Rural Clean Water Program — technical assistance and cost sharing in high priority areas
- Soil Conservation District — erosion and sedimentation control agreements with developers and farmers
- Extension Service — information for rural areas, especially of agricultural research
- Soil Conservation Service — technical advice and plans for soil and water problems
- Agriculture Stabilization and Conservation Service — cost-sharing programs for farm and forest development.

Most programs are directed towards agricultural production or erosion and sedimentation control. They are being used more effectively in controlling nonpoint source pollution.

The federal government and many states also operate regulatory programs for several nonpoint source pollutants. The National Pollutant Discharge Elimination System (NPDES) permit program now covers major agricultural pollution sources such as animal feedlots of 1,000 head or more. At the state and local levels nonpoint source regulations mainly involve erosion and sedimentation controls. Sixteen states and hundreds of communities have sediment control laws.

Mining

Mining can result in severe land disturbances that are expensive to correct. Since mining costs and environmental damages are large, few incentives exist for voluntary nonpoint source controls. An alternative is mining regulations. This has been done at both the state and local levels. All states in which coal is mined have reclamation laws.

The federal government is becoming more involved in regulating mining. The NPDES permit program controls point sources from mines such as ditches and pipes. Since 1977 pollution from coal strip mines has been subject to federal control. In most states certain mining forms — sand, gravel, phosphates, and other non-metallic minerals — are only minimally regulated.

Mining regulations should include the following elements:

- Requiring permits for mining and mining exploration
- Incorporating BMPs into permits
- Providing inspections, corrective action orders, and penalties such as stop-work injunctions for violations
- Requiring pre-mining planning for ground and surface water protection, land reclamation, and mine entrance sealing
- Requiring performance bonds, pollution control plans, and reclamation plans for every operation
- Establishing an abandoned mine pollution abatement program.

Several lessons can be learned from existing programs. Well-operated regulatory programs require substantial resource commitments. Advisory groups should sort out federal, state, and local programs that deal with nonpoint source problems from land disturbing activities. Advisory groups can help identify cost-effective BMPs keyed to local and area conditions.

Silviculture

As compared to agriculture and mining, nonpoint source problems in silviculture (forestry) are less widespread. Only a few states or areas, principally the West and Southeast, identify forestry activities as a major contributor to nonpoint source pollution. These problems are based upon many factors including:

- Land ownership patterns
- Forest managers with varying degrees of experience and knowledge of BMPs in silviculture
- Unenforced local and state regulatory programs for logging operations
- Legal-institutional-financial tools applicable to silviculture, but not fully coordinated for this purpose.

Federal lands are guided by the expertise and authority of the Forest Service and the Bureau of Land Management. These agencies provide financial and technical assistance to state and private landowners. In several regions water quality management controls are incorporated into contracts for timber sales on public lands. The large commercial forestry operations also have professional competence.

Many western states regulate silvicultural activities through various kinds of Forest Practice Acts. The other region having large private holdings, the South, has relied upon non-regulatory means such as education.

A whole range of financial, institutional, and legal tools apply to silvicultural activities. The NPDES permit program applies to four activities considered point sources: rock crushing, gravel washing, log sorting, and log storage. Other federal permits are associated with the Corps of Engineers Section 404 Regulations, the Fish and Wildlife Coordination Act, and wetland acts.

Many states depend upon voluntary compliance with forest practice standards. More effective enforcement often results from:

- A state erosion and sedimentation control law such as Pennsylvania's Clean Streams Act which can be used to monitor forestry-related erosion
- Performance bonds for correcting damage to fragile areas or streams caused by irresponsible operators
- Training, testing, and licensing forest operators
- Interagency cooperation and coordination between forestry, land use, and water quality agencies.

Although some programs are not originally forestry-oriented, many are authorized to deal with silvicultural problems. Advisory groups should identify existing laws, agencies, regulations, incentives, technical assistance, and programs that are applicable to silvicultural activities. Their collective action may be all that is necessary for dealing with nonpoint source pollution.

Unreclaimed strip mine waste and garbage dump.

Best Management Practices

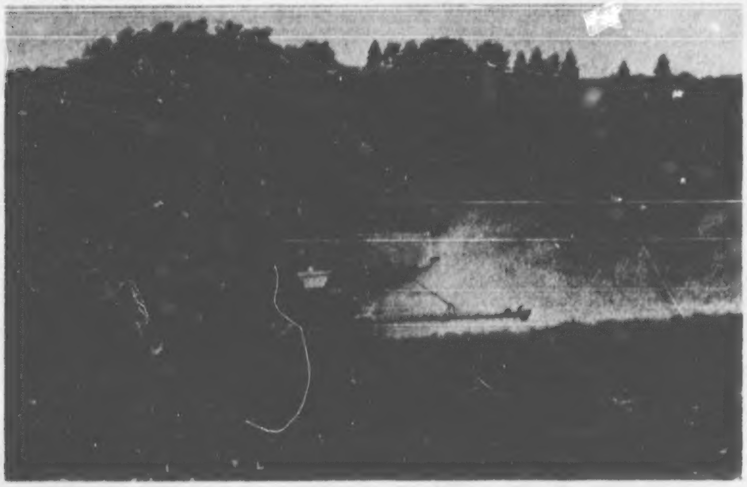
Identifying Best Management Practices (BMPs) is one of the most important tasks in nonpoint source planning. These control techniques include the most effective and practical means of preventing or abating nonpoint source pollution. The selection of BMPs involves assessment of nonpoint source problems, examination of alternatives, and public participation.

Although nonpoint source BMPs generally are less expensive than are wastewater treatment facilities, they can demand significant finances and manpower. For example, the cost of controlling acid mine drainage in Pennsylvania has been estimated at more than a billion dollars.

In past 208 plans the BMPs approved by the United States Environmental Protection Agency (EPA) were ones that were determined to be the most cost-effective. Although the EPA relies upon previous experience for feasibility and cost-effectiveness, innovative approaches are encouraged. The magnitude of nonpoint source problems and the cost of conventional remedies, especially in mining, have sparked new interest in alternative approaches.

Control methods and strategies are of two kinds: nonstructural measures and structural modifications. Structural solutions involve the construction of physical devices for delaying, blocking, or trapping pollutants such as sediment. Nonstructural approaches use an array of techniques that are less physically-oriented, such as work schedules, zoning ordinances, and farming practices.

Timely application of soil nutrients avoids nonpoint source pollution.



Agriculture

In more than two-thirds of the river basins in the nation, agriculture is the most widespread cause of nonpoint source problems. The regions most affected by this pollution are the Central, Southwest, and Island regions. Many activities cause these problems.

Crop production can degrade water quality by contributing to soil erosion by water and wind; by using fertilizers in such amounts or at times that they run off into surface waters or leach into groundwaters; by using fungicides, herbicides, and pesticides improperly so that they drain into watercourses, and by allowing irrigation water polluted by chemicals, sediment, and dissolved salts to flow into surface waters or to evaporate on the land.

Livestock can break down stream banks, disturb stream bottoms, and destroy vegetation. Animals can supply wastes and sediment that promote the unwanted growth of aquatic plants in lakes and streams.

Structural techniques for managing agricultural pollution include:

- Cropland control devices such as erosion barriers, and sedimentation basins
- Direct runoff control techniques such as diversion barriers, storage ponds, and drip irrigation systems.

Categories of nonstructural methods include:

- Control of nutrient losses through fewer but more timely fertilizer applications, crop rotations, and control of fertilizer breakdown
- Reduction of pesticide use through genetic breeding, crop rotations, changed planting times, and integrated pest management systems
- Erosion and runoff controls such as tillage techniques, cultivation timing, crop rotations, and changed land uses.

Mining

The impacts of mining extend far from the sites of operations. Although less than two percent of the land surface in any state is disturbed by mining, the impacts on waterways are much greater.

More than 13,000 miles of streams and 181,000 acres of lakes and reservoirs have been affected by pollution related to strip, open pit, and underground mines. Sediment, acid, and chemicals that are leached from surface mines and mine wastes pollute both ground and surface waters. The Surface Mining Control and Reclamation Act of 1977 attempts to remedy some of these problems.

Nonpoint source control programs in mining are aimed at minimizing site erosion, saving and replacing topsoil for continued vegetative growth, restoring area landforms to pre-mining conditions, and protecting nearby ground and surface waters from pollutants.

Specific Best Management Practices for controlling pollution from active and abandoned mines exist, but they may be very expensive. Preventive techniques are more effective than are measures for dealing with abandoned operations. Principal approaches to the prevention and abatement of pollution from mines include:

- Keep polluting materials away from watercourses
- Rapidly stabilizing the land surface through topsoil reuse, mulching, and revegation
- Neutralizing or preventing toxic substances from forming.

Silviculture

High-quality waters in forested areas historically have been used for water supply and fishing purposes. Water quality degradation in these areas often is due to silvicultural practices.

Silvicultural activities involve the cultivation, harvest, and transport of timber. In certain areas these activities significantly influence the water quality of streams and lakes. The types of pollution associated with silviculture include: pesticides, herbicides, fertilizers, and fire-retardant chemicals; sediment and nutrient losses associated with erosion of harvest sites, log landings, logging roads, and skid trails; organic matter and woody debris in watercourses; thermal damage from increased water temperatures where trees along streams have been removed.

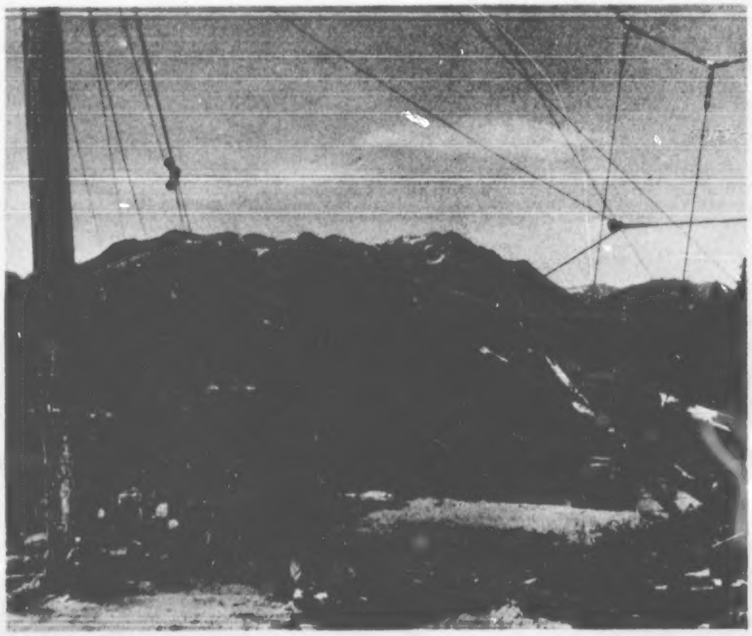
All harvesting techniques, especially clearcutting where an entire stand of trees is taken down, have potential for soils disruption and sedimentation. However, the erosion of roads and trail systems is the greatest source of sediment from logging. The BMPs for reducing sediment from these sources involve:

- Constructing roads and skid trails to minimize erosion
- Protecting streamside management zones from the destruction of ground cover and soil disturbances. BMPs may require the transportation of logs by aerial cables rather than skid trails, and the prohibition of tracked and wheeled vehicles from the zone.

In addition to mitigation measures associated with roads and trails, other BMPs for silvicultural activities involve:

- Schedules of logging operations
- Controls of fertilizers, herbicides, and pesticides.

An extensive array of BMPs is available. With the exception of certain irrigation problems, technologies exist for abating or preventing most types of nonpoint source pollution. Yet, nonpoint source pollution has been identified as a major deterrent to reaching the 1983 national water quality goals.



Aerial transport of logs.

Who Me?

As compared to the readily identifiable point sources of pollution, nonpoint sources often are widely dispersed. It is difficult for citizens to locate them, and to realize their overall magnitude. Citizens may erroneously regard their own agricultural runoff and other nonpoint source pollutants as minor contributions to water problems. Many individuals do not take responsibility for instituting the appropriate BMPs without the encouragement or prodding of regulatory agencies.

Advisory groups can help in the major educational effort that is needed regarding nonpoint source pollution.

Pines planted on eroded slope.

Future Planning

Nonpoint source planning, especially under federal programs, is changing. The 208 grants program is gearing down. Subject to work needs and funding levels, the grants may end after fiscal year 1983. Of course, this is not the end of nonpoint source planning, but it does mean changed directions and organization.

During this final stage of the 208 program, a major emphasis is being placed on prototype projects for financial and technical solutions to various kinds of problems. This planning takes an applied problem-solving focus, rather than the more comprehensive orientation of the past. Advisory groups can continue their participation in identifying problems, developing alternatives, and evaluating results. They can help push plans towards implementation — making sure that problems are being solved.

In the future nonpoint source planning will become more a part of the overall planning process, rather than programs with special grants and separate organizations. Advisory groups can have major inputs into this restructuring effort. Since nonpoint source planning will have more of a local focus, and local funds may provide the main support, advisory groups should see that program changes fit local needs. Various options exist such as cost sharing and legislation. Through evaluation of these opportunities, advisory groups can influence the future planning for nonpoint source pollution.

Nonpoint Source Pollution in the USA

Agriculture

Connecticut
Agricultural erosion statewide has been determined to be over 12 tons/acre/year (acceptable levels are generally 3 to 5 tons/acre/year). This problem is especially noticeable in Lake Waramug and the Housatonic River, impairing recreation and water supply uses.

Delaware
Rural nonpoint pollution sources (agriculture, animal wastes, and rural septic systems) are causing coliform and nitrate problems in groundwater drinking supplies in Sussex County. Water quality standards violations have been documented (60-100 mg/L nitrates; the standard is 10 mg/L nitrates).

North Carolina
The Chowan River has had severe algal blooms which affected the fishery resources, ruined beaches, and resulted in objectionable odors and deposits of decaying algae. About 85 percent of the nitrogen input is from nonpoint sources, with agricultural areas accounting for 50 percent of the total.

Louisiana
Lake Providence and Round Lake have deteriorated due to sedimentation and pesticide residues from agricultural nonpoint sources; private and commercial fishing have been banned by the state in Lake Providence because pesticide levels in the fish violate standards.

Nebraska
Eastern and central parts of the state are adversely affected by sediment, animal wastes, and agricultural chemicals, causing violation of standards for nitrates, turbidity, fecal coliform, and total dissolved solids. Over 1.5 million acres have been identified as nonpoint sources of pollution.

North Dakota
In the Souris River nutrients and suspended solids from agricultural activities have violated water quality standards. They are exceeded 80 percent of the time, and nonpoint sources account for 90 percent of the pollutant load. The area has experienced major duck kills. The state has identified 10,000 acres as high priority for treatment.

Wyoming
Eutrophication of the Flaming Gorge Reservoir is being caused by phosphorus loadings, 78 percent of which comes from nonpoint sources. The Big Horn River is similarly affected, as is the Yellowtail Reservoir where nonpoint sources contribute 99 percent of the phosphorus load. Sources of phosphorus are agricultural fertilizers, septic tanks, feedlots, and erosion.

Silviculture

Oregon
Eight priority areas with water quality problems related to silviculture (Southwest part of North Coast Basin, Yamhill River, South Fork of Umpqua River, part of Goose/Summer Lakes Basin, Crooked River, Malheur River, and Umatilla River) have been identified. Water quality problems involve erosion and sedimentation, excessive debris, high water temperatures, and algal growths.

Washington
Six priority areas having water quality problems (Willapa Bay, Kaloma River, part of Skykomish River, part of Snohomish River, Newaukum River, Deschutes River) are identified. These water quality programs involve sediment, temperature, and wood debris.

Maine
A survey of 350 sites indicates that 10 percent have sedimentation problems causing localized stream impacts; 25 percent have excessive erosion. Spraying pesticide for spruce bud worm control on 23 million acres has resulted in fish kills.

California
Paralleling a trend in other states, Californians are increasingly concerned about herbicides and pesticides used in forestry operations. In a referendum in Mendocino, California, residents voted by a 2 to 1 majority to ban the use of 2, 4, 5-T and Silvex biocides.

Mining

Pennsylvania
The Commonwealth of Pennsylvania estimates that 2,600 miles of its streams are continuously in violation of water quality standards, and another 1,200 are intermittently in violation — all a result of acid coal mine drainage. About 76 percent of the stream miles that are degraded are due to abandoned mines alone or in combination with other sources.

California
California has identified about 200 miles of its streams affected by inactive mining operations. Although the extent of polluted streams is small, important areas are affected. Some abandoned mines are located in park lands, and others are in watersheds that provide water supplies to portions of the San Francisco metropolitan area.

Case Study

Erosion and Sediment Controls

Helena, Montana

Adapted from Water Quality Management Accomplishments Compendium 1. *Document Number EPA-440/3-77-026. Washington, DC: U.S. Environmental Protection Agency, December 1977. 95 pp.*

In June, 1977, voters of Lewis and Clark County, Montana, approved a sediment control ordinance to deal with serious water pollution in their area. The ordinance and its approval were achieved as a result of public participation and technical assistance provided under a water quality management program demonstration project.

These actions began when, in response to the 1972 Federal Water Pollution Control Act Amendments, the Montana legislature requested the Montana Department of Natural Resources and Conservation to head up a study of sediment control problems and legislative issues. The study yielded three major findings: (1) erosion is a serious water pollution problem in Montana; (2) existing enabling legislation provides sufficient authority to address erosion; (3) any sediment control program should be locally administered and enforced.

The Montana Conservation District laws permit local conservation districts to develop soil conservation ordinances, subject to adoption by local referendum. The ordinances are administered locally and enforced through Conservation District Courts. This enabling legislation had never been used prior to the demonstration project.

Lewis and Clark County was selected for this pilot program because it was willing to participate, and its land use patterns and erosion problems are a typical example of Montana conditions. Most of the land in the county is equally divided between federal and private ownership. Agriculture is the primary industry. Most operators raise livestock. Accordingly, the largest land use in the county is rangeland, which accounts for 65 percent of the acreage, followed by forests with 25 percent of the total.

The major sources of erosion and sedimentation are: (1) subdivision development in the urbanized area (the county does not include the incorporated cities of Helena and East Helena); (2) irrigated agriculture; (3) overgrazed rangeland.

Technical Assistance and Public Involvement

The combination of technical staffing and public involvement in the form of two policy advisory committees permitted state and local officials to work with citizens towards implementation of a sediment control ordinance.

Technical staff members were hired through the 208 funded demonstration project. They included: (1) a program manager hired by the Lewis and Clark County Conservation District; (2) a water quality specialist hired by the Montana Department of Health and Environmental Sciences; (3) a sedimentologist hired by the Department of Natural Resources and Conservation.

Two policy advisory committees (PAC) at the state and local levels were established to assist the Conservation District in developing land management practices and the sediment control ordinance. Both the 25-member state PAC and the 60-member local PAC addressed the following subjects: irrigated cropland, dry cropland, rangeland, forest land, construction and subdivisions, information/education, and financing/cost-effectiveness.

The public involvement process emphasized the following advantages of sediment control: (1) good conservation practices pay rewards; (2) stewardship of the soil resource is necessary for future generations; (3) prevention of soil erosion is less costly than remedial measures; (4) local control and administration of erosion and sediment control regulations is efficient; (5) accelerated soil erosion and the resulting sediment may violate state water quality standards.

Best Management Practices

The sediment control ordinance incorporates Best Management Practices developed by: the Soil Conservation Service for agriculture; the Montana State Forestry Committee for silviculture, and the Lewis and Clark County Conservation District for subdivision construction. These Best Management Practices are based on site-specific soils, climate, and use characteristics.

Financing of Best Management Practices

Since financing of Best Management Practices depends on local acceptance of the sediment control ordinance, it would have been premature for the pilot program to specify funding sources before the referendum had passed. The Lewis and Clark County study nonetheless identified potential funding sources at all levels of government.

Agricultural Stabilization and Conservation Service cost-sharing and Small Business Administration low-interest loans were identified at the federal level. Two possible state sources were proposed: an appropriation from the state legislature for operating costs, and grants or low-interest loans from the Montana coal severance fund according to the state's 1975 Renewable Resources Act. The Lewis and Clark County Conservation District was also authorized to levy a property tax of 1½ mills, part of which might be applied to support the operating expenses.

Most of these funding sources cover only part of the cost of the Best Management Practices. Local ranchers, farmers, and developers help pay for the sediment and erosion controls. This willingness to cooperate by the various parties led to the passage of the Lewis and Clark County sediment control ordinance.

Implementation

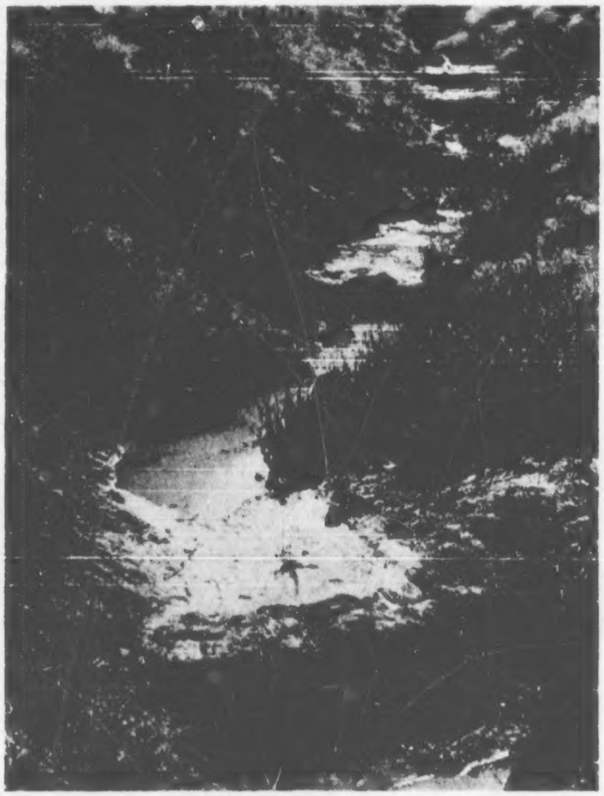
The primary means of complying with these practices is through a Conservation District-approved erosion and sediment control plan. Erosion and sediment control plans are optional for agricultural activities, as long as standards are met or exceeded and no erosion problems occur. However, they are mandatory for most construction and subdivision activities. In addition, logging operators must either prepare erosion and sediment control plans, or give the Conservation District notice before starting forestry activities.

Any land occupier, Conservation District supervisor, or state and county water quality official may file a complaint alleging that accelerated erosion or sediment damage has taken place. If a violation of the ordinance is verified by the Conservation District, the land user is given an opportunity for voluntary compliance. If the violation is not corrected, the District Supervisors are authorized to issue stop work orders and/or impose fines of up to $500 per day.

Significance

Increased public awareness of nonpoint source pollution and support for Best Management Practices to improve water quality are crucial in developing a water quality management program. The case of Lewis and Clark County illustrates this point. The county possessed the enabling legislation for establishing sediment and erosion controls, but it lacked a widespread local commitment to solve this nonpoint source problem.

Public participation and technical assistance funded by the 208 program were the missing links. The water quality management program enabled concerned state and local officials to work with citizens, and build consensus for implementing Best Management Practices designed for local conditions.



Wire dams holding silt in gully.

Need More Information?

Publications

Forest Harvest, Residue Treatment, Reforestation and Protection of Water Quality. Washington, DC: U.S. Environmental Protection Agency, April 1976. 273 pp. Order #2815A.

Methods and Practices for Controlling Water Pollution from Agricultural Nonpoint Sources. Washington, DC: U. S. Environmental Protection Agency, October 1973. 83 pp. Order #2117.

Methods for Identifying and Evaluating the Nature of Nonpoint Sources of Pollutants. Washington, DC: U.S. Environmental Protection Agency, October 1973. 261 pp. Order #0002.

Water Quality Management Guidance for Mine-Related Pollution Sources (New, Current, and Abandoned). Washington, DC: U. S. Environmental Protection Agency, December 1977. 198 pp. Order #4301.

> These EPA publications are helpful in monitoring and evaluating nonpoint sources of pollution. They give the impacts of various agricultural, silvicultural, and mining activities on water quality. Specific best management practices for control of these pollution sources are described in detail. Policy aspects are not discussed in depth. They may be obtained from U.S. Environmental Protection Agency, Library Services, Mail Drop 35, Research Triangle Park, NC 27711.

Institutional Basis for Control of Nonpoint Source Pollution Under the Clean Water Act — With Emphasis on Agricultural Nonpoint Sources. Washington, DC: U.S. Environmental Protection Agency, November 1979. 165 pp. Order #37175.

> Written in layman's language, this document discusses nonpoint source pollution history, policy, and regulatory arrangements. The first part gives insights into federal planning provisions for nonpoint source controls, legal aspects, EPA regulations, and court decisions. The second half of the document gives synopses of agricultural laws, agency and program arrangements, and funding sources for nonpoint source controls in selected states. Extensive footnotes and references are provided. It is available from the Forms and Publications Center, U.S. Environmental Protection Agency, Mail Drop 41, Research Triangle Park, NC 27711.

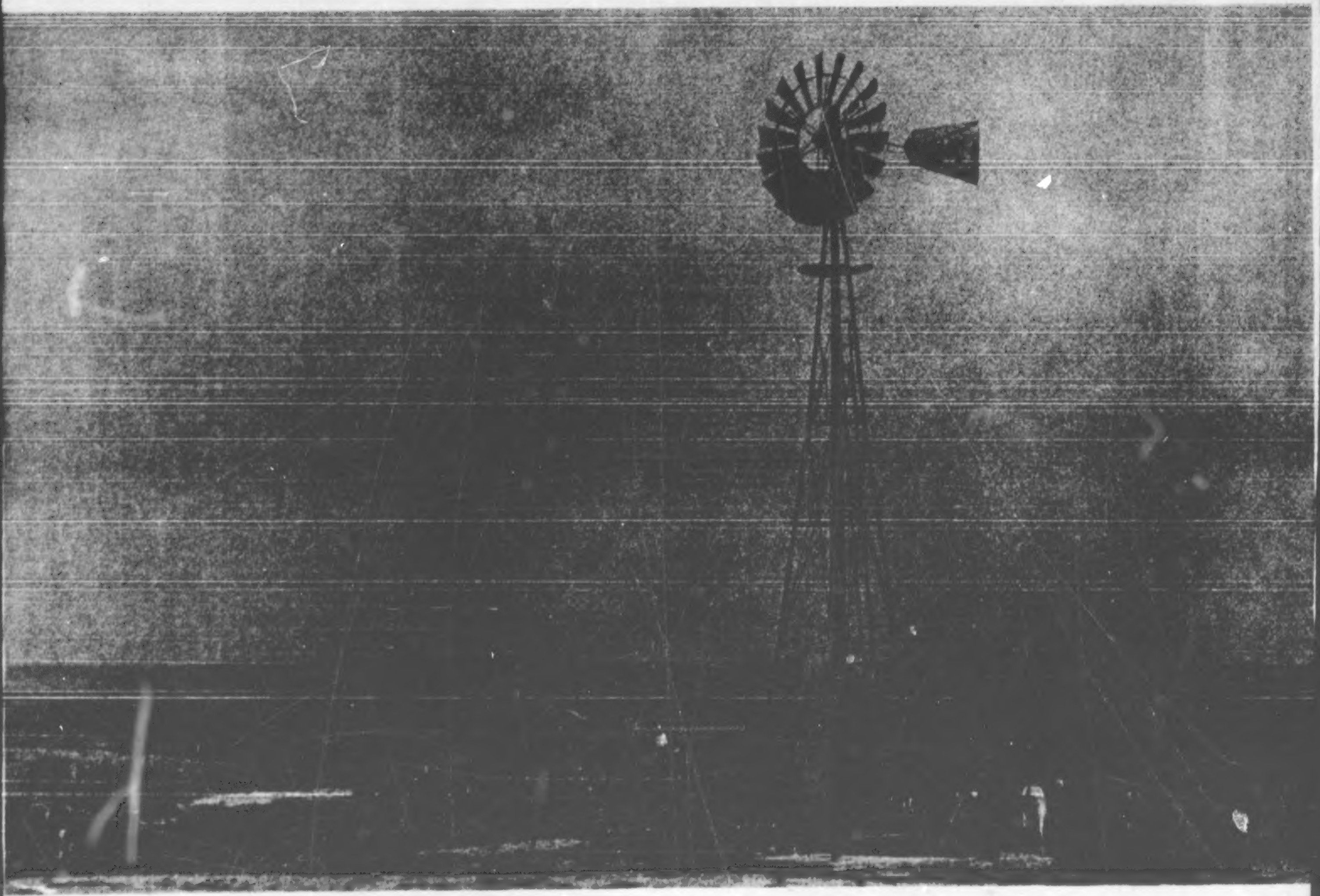
Nonpoint Sources of Pollution Fact Sheets. Sheet Numbers 1-6. Washington, DC: U. S. Environmental Protection Agency, November 1978. 6 pp. Order #36852.

> These sheets provide brief introductions to nonpoint source problems, programs, legislation, best management practices, and citizen action. They may be obtained from the Forms and Publications Center, U.S. Environmental Protection Agency, Mail Drop 41, Research Triangle Park, NC 27711.

Audiovisual Materials

Slide-tape presentations on nonpoint source pollution

> Twelve slide trays and tapes cover an introduction to selected nonpoint sources of pollution, agriculture, construction, mining, silviculture, and legal/institutional considerations. Specific areas, especially BMPs, are discussed in detail. The programs are long (2-3 trays of slides per program), but technical matters are covered. Policy considerations are minor. The materials are available from either the regional or national EPA offices (Water Planning Division).
>
> Other slide-tape programs and films are available from conservation districts, agricultural extension services, the Soil Conservation Service, and state agencies in agriculture, mining, and forestry.



Chapter 18

Groundwater Contamination

Geraghty & Miller, Inc. and Charles A. Cole

Of all the kinds of pollution that are degrading our physical environment in the United States, probably the least recognized is the declining quality of groundwater.

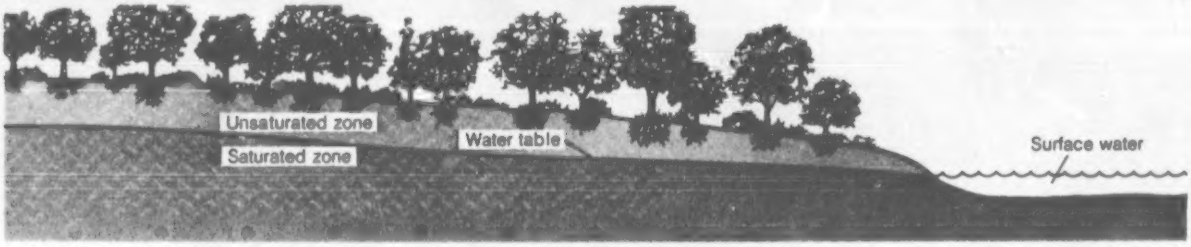
Groundwater is the largest source of fresh water available to and commonly used by humans. Its deterioration will have a major impact. It underlies the earth's surface almost everywhere, beneath mountains, plains, and deserts. However, it is not always accessible. It may occur close to the land surface, as in a marsh, or it may lie hundreds of feet below the surface, as in arid areas of the West. Some water, especially in very shallow zones, may have been in the ground just a few hours and may be vulnerable to contamination from surface land uses. At great depths, the water may have accumulated for hundreds of thousands of years and often is free from contamination.

Groundwater Occurrence

It is difficult to picture groundwater. Some people erroneously imagine it occurring as an underground lake or river, in an attempt to relate groundwater to familiar surface features. In fact, groundwater is simply water that fills the pores and cracks in subsurface rocks and sediments.

Groundwater has several distinctive features. The *water table* is the top surface of the groundwater. Below the water table, all the available pores and cracks are filled with water; the rock is saturated. There is some water above the water table in the unsaturated zone, but this water adheres to the soil particles and will not flow to a well.

Groundwater flows through underground formations or layers called *aquifers*. An aquifer is a layer or zone below the surface of the earth that can yield water. Groundwater moves from areas of high pressure to those of low pressure in the aquifer, in other words, down the pressure gradient. However, this is not always from high to low ground elevation. Groundwater can also move upward when it is confined under pressure between impermeable layers such as clay or shale. If an aquifer, confined under pressure, is pierced by a well, water will rise above the top of the aquifer and may even flow from the well. Water confined in this way is said to be an *artesian aquifer*. Groundwater in deep aquifers far below the surface of the earth may be the result of water seeping through the rock for centuries. The process is so slow that wells can withdraw this groundwater faster than it can be replenished. As a result water tables fall and can be reached only by deeper and deeper wells.



Groundwater Importance

Ninety-five percent of the world's fresh water, excluding glacial icecape, is found in the ground. About one-half of the population of the United States depends upon groundwater as a source of drinking water. Of the total U.S. population, 29 percent use groundwater delivered by community systems, and another 19 percent have their own domestic wells. In addition, millions of Americans drink groundwater from wells serving industrial plants, office buildings, restaurants, gas stations, recreational areas, and schools. The level of dependence upon groundwater ranges from 92 percent in New Mexico to 30 percent dependence in Maryland and Pennsylvania. Almost all of the rural population uses groundwater from private sources. It is usually simpler and cheaper to install a domestic well than to transport and treat surface waters.

There are many reasons why groundwater has become a major source of drinking water in the United States:

- Accessibility
- Purity
- Supply
- Reliability.

Groundwater is more widely available and accessible than surface water. A domestic or farm well can be successfully constructed almost anywhere. Historically, most groundwater has been "pure" and safe to drink. Over one-third of the nation is underlain by aquifers generally capable of yielding large volumes of groundwater. The present utilization of groundwater over much of the United States is small compared to the total potential supply. The withdrawal rate is about one-tenth of recharge rate. The evaporation losses of groundwater, as compared to surface water, are minimal except in areas where groundwater occurs at a shallow depth. Groundwater also is a relatively reliable source, not subject to the rapid and sometimes great fluctuations in availability characteristic of most surface waters.

Florida. The total volume of fresh groundwater stored in Florida's aquifers exceeds the combined surface storage of the Great Lakes.

Drilling for groundwater.

Groundwater Chemical Quality

Groundwater has distinct advantages over surface water as far as natural water quality is concerned. The temperature of groundwater is usually constant throughout the year. Also, because of the efficient filtering action of the soil and rock as water percolates downward, groundwater is normally free of organisms and suspended solids, and usually requires little or no treatment.

Groundwater contains dissolved minerals which it picks up as it flows through the layers of the earth. Most of these minerals are harmless. Some are desirable, for they give pleasant taste and may even enhance health. However, some constituents are harmful and a few may be toxic. In a few isolated cases, significant concentrations of hazardous substances such as arsenic and radioactive elements have been found to occur naturally. These instances are related to the unique geological materials of the aquifer.

Within a large body of groundwater, the natural chemical composition of water tends to be relatively consistent, although the concentrations of individual minerals may vary from place to place. The natural quality of groundwater varies little over time. The most common chemical constituents of groundwater are metals such as calcium, magnesium, sodium, and potassium, and minerals such as carbonate, bicarbonate, chloride, and nitrate.

High concentrations of certain minerals can cause problems. Too much sodium may be harmful to those who have high blood pressure. Excess iron and manganese can stain plumbing fixtures and clothing. Excessive amounts of naturally-occurring fluoride can disfigure teeth; however, small amounts appear to be beneficial. High concentrations of nitrate can cause serious health problems in infants. Two problems of common occurrence around the nation are hardness and salinity.

Hardness is a measure of the calcium and magnesium content of the water. Very hard water is undesirable for many domestic and industrial uses. For example, it interferes with the cleaning action of soaps, and leaves deposits inside pipes, boilers, automobile radiators, and other devices that use water.

Salinity pertains to chemical salts such as common table salt. These substances can corrode metals, conduct electricity, and, at certain concentrations, are harmful to most vegetation and wildlife. For example, if the concentration of chloride, a component of table salt, exceeds 250 milligrams per liter the water is not considered desirable for drinking. *However, water with even a few thousand milligrams per liter is used routinely for drinking in some locations in the United States.*

Groundwater Contamination

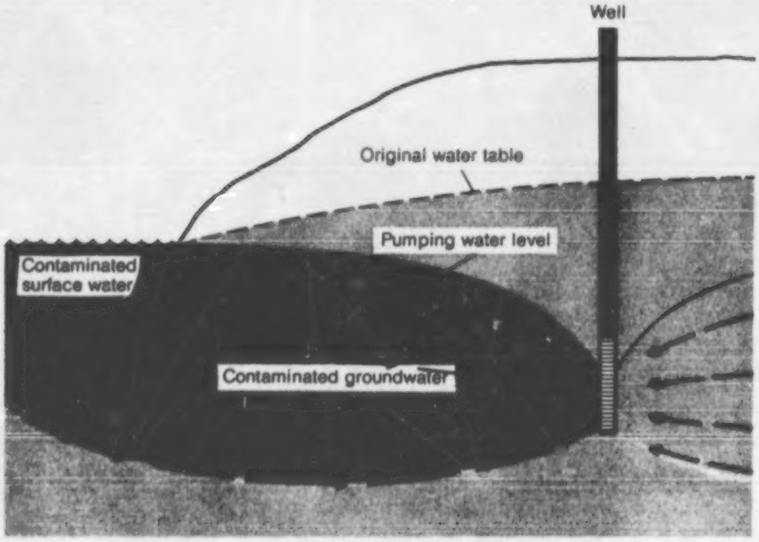
The dumping of liquid and solid wastes into the ground has been going on for a long time. However, the evidence of damage to groundwater quality has only recently begun to show up.

Once in the ground, wastes are hidden from view, but they slowly move through the geologic formations until they enter an aquifer that may be in use as a water supply. While natural processes such as filtration and dilution can reduce the seriousness of groundwater pollution, many wastes remain unchanged for years after they enter a groundwater body. In contrast, contamination of surface water may be corrected quickly by flushing or skimming. The correction of groundwater contamination is usually much more difficult than solving surface water problems. The most effective means for protecting groundwater is to control and monitor potential sources of contamination. Potential pollutants can be amazingly persistent, remaining buried decades before showing up in aquifers.

Meaning of Groundwater Contamination

Groundwater contamination is the impairment of the quality of groundwater by chemical or bacterial pollution to a degree that inhibits the present and future use of the water, or creates an actual or potential hazard to public health.

Minnesota. In 1972 office workers at Perham, Minnesota, became ill shortly after drinking water from a new well. Eleven out of 13 persons were striken with arsenic poisoning, some serious enough to be hospitalized. Local old-timers recalled that excess grasshopper bait had been buried nearby during the mid-1930's. Less than 50 pounds of bait were involved, but the well site was only 20 feet from the disposal area.



Contaminated surface water can be induced to flow to a pumping well.

New York. Toxic organic chemical wastes were buried for many years in an industrial dump near Buffalo. It was last used in the 1950's, and was later converted into a housing development. Chemicals were first detected at the site in the 1970's. Public health problems ultimately caused the relocation of the families in the development. This dump has drawn international attention as the Love Canal.

How can such tragedies come about? Citizen advisory groups may be able to help to prevent their future occurrence.

Types of Contaminants

Most things that contaminate groundwater may be placed in one of three broad groups: biological organisms, inorganic chemicals, and organic chemicals.

Biological Organisms

Biological contamination of groundwater occurs when human or animal wastes enter an aquifer. Microorganisms present in the wastes may be carried by groundwater into nearby wells used for drinking water. *The first time an illness was traced to a well contaminated with sewage was during a cholera epidemic in London in 1854.*

The travel of bacterial pollutants through the ground has been studied by collecting samples from test wells. Indications are that the bacteria seldom travel more than 100 feet from a source. Exceptions are where the aquifer is fractured or cavernous, allowing bacteria to travel rapidly for great distances. Studies also have shown that bacteria are largely removed by filtration. Although most microorganisms die out rapidly in groundwater, bacterial pollution may occur locally:

- In heavily populated suburban areas where numerous septic tanks discharge large quantities of waste into an aquifer
- Near leaking wastewater lines
- From leaks in storm sewers, storm sewer overflows, or flows directly from city streets into the ground
- Near improperly-operating sewage treatment lagoons and ponds
- From poorly designed land-spreading and wastewater recharge operations.

The United States experiences an average of 35 waterborne disease outbreaks each year. During the period 1971-1977, a total of 192 outbreaks affected 36,757 persons. Two deaths were associated with these events. Almost half of the total outbreaks and illnesses were related to groundwater supplies. No level of disease-causing organisms is permissible in drinking water.

Advisory group members may know of local instances where illnesses occurred from contaminated wells.

Inorganic Chemicals

Inorganic chemicals are substances of mineral origin. They are not derived from living matter.

Inorganic chemical contamination differs from biological contamination in a couple of important ways: the persistence of the pollutants, and the difficulty of their removal from water.

The U.S. Environmental Protection Agency (EPA) has set standards for the maximum permissible concentrations of certain substances in drinking water. For example, the standards require that concentrations greater than 0.05 milligrams per liter of toxic elements such as arsenic and chromium will jeopardize a groundwater source for drinking purposes. Levels of cadmium greater than only 0.01

milligrams per liter will also threaten this use of the source. Excessive concentrations of arsenic, cadmium, and chromium in groundwater are often found where electroplating wastes have been discharged into the ground. Lead can get into the groundwater where gasoline has entered the aquifer through leaking pipelines, service station tanks, or surface spills.

Advisory group members may be aware of old lagoons or petroleum tanks that may be causing groundwater pollution.

Organic Chemicals

Organic chemicals are substances containing predominantly carbon, hydrogen, and oxygen. The presence of other chemical elements may make them quite toxic to humans.

Organic chemical contamination is most often caused by:

- Solvents used for degreasing septic tanks
- Spills and leaks of oils and gasoline
- Industrial, municipal, and other wastes disposed on land.

Septic tanks and cesspool degreasers contain solvents that open the pores in the absorption field pipes. The compounds are resistant to decomposition and are flushed into the aquifer. These products are sold on the retail level in small quantities, and may cause widespread regional deterioration of groundwater quality.

New York. A study done in Nassau County, Long Island, investigated the extent of suspected carcinogenic contamination in the area's groundwater. The heaviest and most widespread contamination was found in the most shallow glacial aquifer, which extends to less than 200 feet depth. Twelve public water supply wells that supplied most of the county's drinking water were located in a aquifer at 800 feet depth. These wells also had to be closed due to contamination.

A petroleum spill will form a pool on the top of the water table. In the case of gasoline, there are lighter components such as benzene that move out quickly from the center of the spill in the direction of groundwater flow. The presence of benzene in groundwater from gasoline contamination is a particular problem, because it has been associated with leukemia.

There are many different kinds of organic chemical contaminants associated with industrial wastes. They represent a complex group of by-products and compounds produced with major industrial products. Their analysis requires expensive instruments and complicated techniques. Their diversity also causes pollution control problems. The EPA has set maximum permissible concentrations in drinking water for only some of these substances.

The contamination of groundwater by organic chemicals may be the most serious form of pollution that the advisory group must face.

Sources of Groundwater Contamination

Cesspools and septic tanks

Septage and night soil disposal

Land application systems

Leaky sanitary and storm sewers

Leaks in oil and other pipelines

Waste retention ponds and lagoons

Contaminated rivers or lakes

Seepage from sanitary landfills and open dumps

Agricultural activities using insecticides, herbicides, and fertilizers

Animal feed lots

Irrigation water

Highway deicers such as salt

Mine drainage

Salt-water intrusion

Upward movement of salty groundwater

Accidental or deliberate spills

Waste disposal wells

Oil-fired brine wells

Causes of Groundwater Contamination

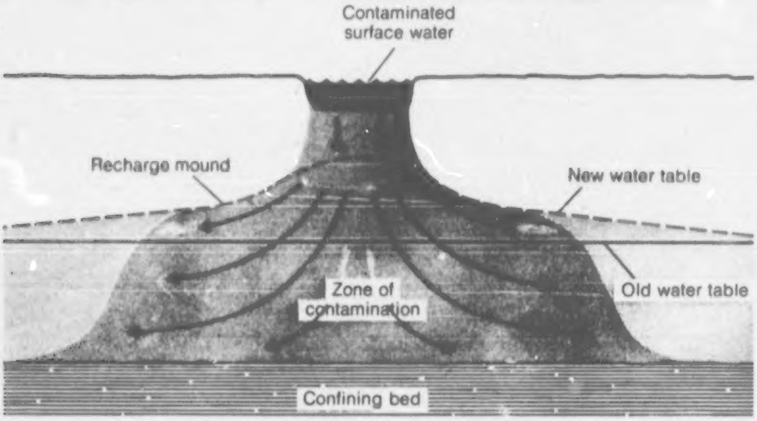
Every day, a wide variety of harmful substances are introduced into the aquifers of the nation. Sources of pollution include: landfills and dumps, cesspools and septic tanks, ponds and lagoons, spills, waste disposal wells, saltwater intrusion, and agriculture.

Landfills and Dumps

One newly recognized threat to groundwater quality is improperly-designed solid waste disposal facilities. Presently, nearly 200,000 landfills and unauthorized dumps are operated in the United States. This quantity does not include the large number of abandoned facilities. At some sites, wastes are dumped into places which are saturated with groundwater. However, even if the eastes are not indirect contact with the groundwater. However, even if the wastes are not in direct contact with the concentrated *leachate* that percolates downward to the aquifer. The leachate may be high in organic and mineral acids and can seriously affect the groundwater quality.

California. The Regional Water Quality Control Board, of the Central Valley Region found that a chemical manufacturing company near Sacramento had been illegally disposing of chemical wastes. Trichloroethylene, a grease solvent, was detected in many wells both on and off the plant site. Other organic and inorganic contaminants were also found in the groundwater. People were advised not to use water from these wells for drinking or cooking.

Water moving downward in a recharge area can create a dome, thereby reducing the ability to cleanse the percolating water.



Cesspools and Septic Tanks

Cesspools and septic tanks are another source of measurable pollution in many localities. This source is significant for two reasons: in rural areas, most wastewater is processed by onsite systems such as septic tanks; much of the nation's soil is unsuitable for the use of conventional septic tanks. Approximately eight-five percent of the land in Pennsylvania, for example, is unsuitable.

Michigan. A sudden outbreak of infectious hepatitis was traced to groundwater contaminated by septic tank effluent that traveled through fractures in limestone to the water table, and then spread to domestic wells.

Pits, Ponds, and Lagoons

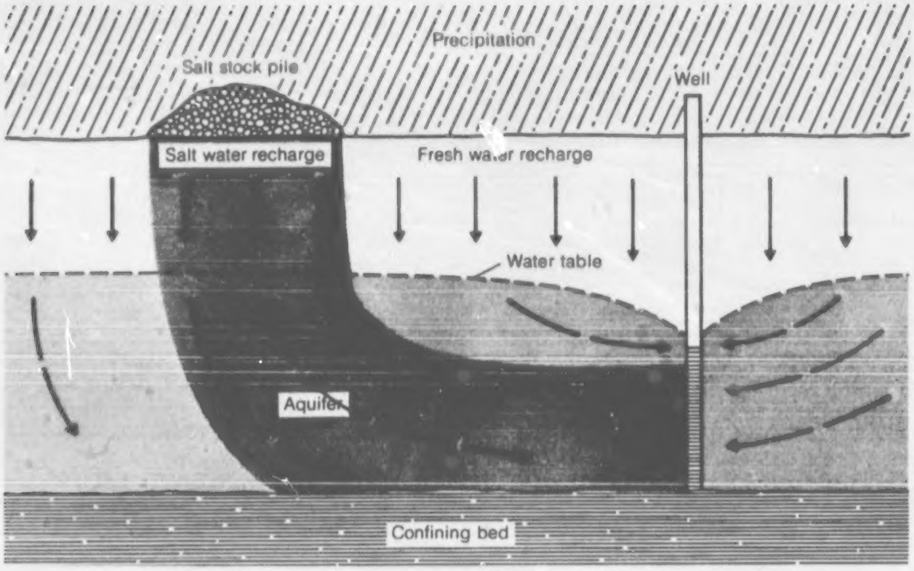
Disposal of industrial wastes in pits or waste lagoons is another widespread practice. It is of particular concern for potentially toxic materials. Also, lagoons are becoming increasingly prevalent among agro-businesses such as cattle and pig feedlot operations.

Spills

Percolation of liquids spilled at the land surface can be another serious threat if the ground is permeable and allows downward percolation. For example, many petroleum spills penetrate into the ground, travel downward, and come to rest on top of the water table. Underground storage of chemicals, chemical wastes, or petroleum products in steel or concrete tanks presents a potential hazard because metal corrosion or concrete deterioration may ultimately permit seepage of contaminants into an aquifer.

The leaching of soluble solids stored on the land surface is another practice that can be responsible for the contamination of groundwater. These situations occur, for example, where rainwater dissolves soluble materials from piles of salt or coal mine wastes, and enters the ground.

New Jersey. Fifteen-hundred oil and hazardous substance spills were reported from April 1977 to June 1978, according to the New Jersey's Office of Hazardous Substances Control. The spills involved 330,000 gallons of hazardous substances.



Contamination of a water table aquifer by leaching of surface solids.

Waste Disposal Wells

The injection of liquid wastes through wells into porous and permeable rock formations, is a comparatively new practice that also threatens some groundwaters. Chemical, petro-chemical, and pharmaceutical companies operate many injection wells across the country. These wells are usually designed to inject or discharge waste fluids into saltwater-bearing rocks. However, in some instances leaks at the well head, fractures in rock layers, and equipment failures have caused serious contamination of fresh groundwater sources.

Michigan. Domestic animals and people became ill in Hemlock, reportedly from drinking contaminated water. Although the exact cause remains unproven, various tests have turned up a vicious stew of toxic chemicals: toluene, carbon tetrachloride, phthalates, TCE, PCB, PBB, and others. Suspected sources are the many industrial injection wells which dot the area.

Saltwater Intrusion

Another kind of groundwater contamination takes place when saline water enters into a freshwater-bearing aquifer. This saltwater intrusion occurs mainly in coastal areas, where pumping has decreased the natural flow of fresh groundwater toward the oceans and seas. However, it can also take place in land where pumping induces deep salty waters to move upward into freshwater beds.

Florida. In the Jacksonville area, the chloride concentration of water in wells has increased primarily as a result of saltwater moving into the bottom layers of aquifers, and moving upward into the pumping zones. A computer model and area maps of groundwater chemistry will be used to determine the origin and movement of the saltwater.

Agriculture

Agricultural practices may result in groundwater contamination. Of most serious concern is irrigation return water that becomes increasingly saline as a result of recirculation and evaporation. Groundwater pollution also stems from the wide use of pesticides and herbicides. Groundwater contaminated by nitrates or bacteria has been found near animal feedlot operations.

New York. Seven farm families on the East End of Long Island have been advised not to drink from their wells, because of contamination from a toxic pesticide used to treat potato fields in the area.

Hazardous Wastes

In 1980 alone, 57 million tons of hazardous materials will be discarded. Managing hazardous wastes adequately will require very strict controls and monitoring. The EPA has found that current practices allow 90 percent of the wastes to be discarded in environmentally unsound or dangerous ways.

A U.S. House of Representatives subcommittee has released a list of 3,383 sites for the disposal of chemical wastes. According to various authorities, this list represents only ten percent of the chemical dumps in the country and does not account for the thousands of smaller companies in the chemical industry or another 16 industries that dump toxic wastes.

Underground Movement

The movement of water underground depends on the pressure gradient or slope of the water table, and the composition and thickness of the rock and soil layers. Contamination tends to stay in place in an aquifer where pressure is uniform throughout, and where there is little movement of the groundwater. On the other hand, where the water table is on a steep slope, contaminants gradually spread down from the site. Once at the top of the water table, a contaminant will either float on the water table or penetrate downward into the groundwater body. The contaminant will then move down the pressure gradient with the groundwater toward the ultimate discharge point, which is usually a spring or a river. The pattern of this flow, however, is changed by pumping from nearby wells. In these cases, the water and its load of contaminants will flow toward and into a well.

The thickness and makeup of the unsaturated zone overlying the aquifer are also important factors. A thick soil zone overlying the aquifer, especially in cases of biological contamination, will act to absorb and filter biological pollutants. In the opposite case, where the overlying zone is thin, there may be little retarding or absorptive action, and the pollutant arrives at the water table almost immediately.

The normal rate of flow of groundwater in a typical geological formation is low, on the order of inches per day. Some groundwater, on the other hand, may move at rates up to hundreds of feet per day.

Under natural conditions, almost all water-table aquifers discharge groundwater into nearby surface waters such as a lake or river. Thus, the groundwater is usually entering the stream, and the aquifer itself is not contaminated by any wastes that might be carried in the stream. On the other hand, when a well is put into operation in an aquifer near a stream, groundwater levels are lowered and the pressure gradient between the well and river may be reversed, causing river water to flow toward the well. If the stream is polluted, contaminated water may be induced to flow towards the well.

Deep aquifers are often protected from the contamination of more shallow aquifers by layers of relatively impermeable materials separating the two zones. However, if the zones are connected by abandoned or improperly sealed wells, contaminants can penetrate through these weak points and reach the deeper aquifers. Also, under certain artesian conditions, the contaminants can move upward. In some parts of the country, deep saline water has contaminated shallow fresh water zones through poorly constructed or maintained wells.

Control of Groundwater Contamination

Over the past ten years, the federal and state governments have increased their attempts to prevent waste disposal practices that may cause groundwater pollution. The Clean Water Act of 1977 provides some jurisdiction over waste disposal and nonpoint sources of pollution that can endanger groundwater. State and areawide impacts upon groundwater, including pollution from point and nonpoint sources, such as agriculture, landfills, and lagoons should be identified. Plans for their control can be developed under Section 208 of the Act.

The Safe Drinking Water Act of 1974 requires periodic sampling of drinking water quality at all supply systems, even small ones that serve at least 15 households or serve 25 persons. The Act gives to the states the main responsibility for enforcing the drinking water standards. Another provision requires the local supplier periodically to sample and test water pumped to the taps. The standards for the water establish maximum contaminant levels for ten inorganic chemicals, six pesticides, trihalomethanes (a group of organic substances), bacteria, radioactivity, and turbidity.

Sole Sources

With the passage of the Safe Drinking Water Act, Congress clearly indicated its intent to elevate the level of protection afforded groundwater. Drinking water sources were given special attention. Section 1424 (e) of the Act authorizes the EPA to designate an aquifer as a sole or principal drinking water source, following either studies done by the EPA, or petition by interested groups. Once the designation has been granted, no federal financial assistance may be given for any project which may contaminate the aquifer, so as to create a significant hazard to public health. However, this protection only applies where federal funding is involved.

So far, the EPA has designated several sole-source areas. They include: the Edwards Aquifer in Texas, the Spokane Valley-Rathdrum Prairie area in Washington and Idaho, Northern Guam, portions of Long Island, a portion of the aquifer system under Fresno County, California, the Biscayne Bay in Florida and the Buried Valley Aquifer System of Western Essex and southeastern Morris Counties in New Jersey. Other areas around the country have submitted petitions. Local groups involved in petition requests are numerous. For example, the Spokane designation involved petitions from the Idaho Coalition for Shoreland Preservation, the Spokane Vera Valley Citizens Committee, the Spokane Audubon Society, and the Spokane Sierra Club.

Underground Injection Control Program

A program for the control of wastewater injection also has been established to control groundwater pollution. The EPA estimates that more than 500,000 injection wells, as legally defined, are operating in the United States. Some are injecting reasonably clean runoff and may have environmental benefits. Others, however, dispose of wastes that are highly toxic.

The EPA is required to designate the states that need programs and to set national requirements. The regulations set requirements for five types of wells:

- Deep waste disposal wells
- Oil and gas production wells
- Special purpose wells such as geothermal or solution mining
- Shallow wells for hazardous waste disposal
- Other special categories.

The regulatory requirements for hazardous waste disposal wells injecting into a drinking water source are reserved at this time until the Hazardous Waste Management Regulations are promulgated in final form. Permits on well operators cover: construction, operation, corrective actions, well abandonment, data monitoring and reporting, governmental access to facilities and records, and permit reviews, modifications, and termination.

The Resource Conservation and Recovery Act provides groundwater quality protection by regulating the disposal of liquid or solid wastes and sludges on land. Design specifications have been issued for landfills and facilities that store or treat hazardous chemical wastes. Periodic sampling and analysis of groundwater at these sites is required to detect changes in water quality.

Hazardous Waste Management

Hazardous wastes complicate solid and liquid waste disposal practices. A substance is considered hazardous if it is flammable, corrosive, explosive, or toxic. The Resource Conservation and Recovery Act of 1976 (RCRA) is EPA's main tool for managing hazardous wastes. A primary objective of the Act is managing hazardous industrial waste from production through disposal (cradle-to-grave). The management options in order of desirability include:

- Reducing hazardous waste production
- Separating and concentrating the wastes
- Reusing the wastes
- Incinerating wastes or detoxifying them
- Discarding in secure landfills.

To implement the RCRA, most states will manage their own solid and hazardous waste programs. An estimated $4.1 billion will be needed for solid waste management to protect groundwater.

The EPA has formed a Groundwater Task Force to coordinate the administration of the 1977 Clean Water Act, the 1974 Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the other federal laws having impact on groundwater. Other federal legislation includes the Toxic Substances Control Act, the National Environmental Policy Act, and the Federal Insecticide, Fungicide, and Rodenticide Act. The Task Force will also develop a groundwater protection strategy for the Agency.

Many states have recently passed water pollution laws in response to these federal laws. Some industrial states such as New Jersey have issued regulations concerning the protection of groundwater. In many ways, these state statutes are stricter than the federal laws.

Protection of Groundwater Quality

The importance given to groundwater varies from region to region. Both water quality management (WQM) and facility planning are involved in protecting groundwater.

Water Quality Management Planning

WQM plans emphasize groundwater to different degrees. Generally, where groundwater is important as a source of water for public water supplies, industrial use, or irrigation, the budget and time allocated for a groundwater study should reflect this concern. The consultants and the WQM agency carry out a series of tasks, including a description of the groundwater system, an inventory of groundwater sources, a list of pollution sites, and discussions of groundwater management and protection. The sources of groundwater pollution, including onsite waste disposal, industrial lagoons, landfills, spills and leaks, road salt, and agricultural chemicals must be investigated. Before the impact of pollution sources on groundwater can be assessed, the geology and hydrology of the region also have to be fully understood.

WQM Groundwater Studies

Contribute to a regulatory or management program

Develop Best Management Practices (BMPs), ordinances, and groundwater standards

Monitor, model, or collect data if related to a problem

Provide a basis for implementing a comprehensive groundwater plan related to a WQM water quality plan

The potential severity of a groundwater pollution source may be determined through an analysis of available data, hydrogeologic maps, and a thorough understanding of the groundwater movement. For example, the impact of a landfill on groundwater can be estimated, if the quantity, quality, and direction of flow of both surface water and groundwater have been determined.

The groundwater pollution potential of waste disposal practices in a WQM region should be known at the end of the study. Recommendations are drafted for a management plan that will result in the protection of groundwater quality. This plan may:

- Require the restriction or elimination of waste disposal activities in certain areas where the aquifer is vulnerable to pollution
- Recommend certain control measures to limit pumping near points of existing pollution.

Items of key interest and concern must be identified at an early stage of the work, so that they can be properly investigated.

Members of the advisory group will be able to advise the consultants or state agencies as to the existence of certain information on water quality or waste disposal. Individuals may know of prior disposal sites in some areas that need to be investigated. In addition, the group should monitor the study's progress, and make sure that areas of concern such as quality of drinking water receive adequate attention. Upon assessment of the basic data, the advisory group should discuss groundwater management, waste disposal policies, and the various options that are available to deal with problems in the study area.

Groundwater and WQM Planning

Is groundwater a source of water supply?

What is the quality of the groundwater?

Are materials present that may have come from human pollution?

Are concentrations of toxic materials above the permissible standards for drinking water?

Are there sources of pollution such as dumps that can affect the groundwater?

What can advisory groups do to help protect the groundwater quality?

The advisory group can recommend to the WQM agency options that appear most desirable for managing the groundwater quality. These alternatives include:

- **Limitation or exclusion of waste disposal activities in certain aquifer recharge areas**
- **Development of areas for landfills**
- **Regulations on groundwater withdrawals to prevent the pollution or the depletion of aquifers**
- **Establishment of groundwater monitoring facilities such as wells.**

Facility Planning

Wastewater treatment facilities constructed using federal funds under Section 201 of the Clean Water Act must utilize the best practicable waste treatment technology (BPT). Lagoons and the land application of wastewater effluent and sludge are often the most cost-effective BPTs. Whatever method is chosen, it must protect groundwater.

Groundwater resulting from the land application of wastewater also must satisfy the criteria for intended uses. For example, groundwater that has potential for drinking and does not meet the contaminant levels specified in the National Interim Primary Drinking Water Regulations must be treated before use, adding significantly to costs. However, the existing concentrations of contaminants may already exceed the standards. If this situation occurs, the pollution due to the land application will not be subject to the regulations.

Groundwater and Facility Planning

Are failing onsite treatment systems polluting the groundwater?

Does the improper disposal of waste treatment residuals pollute groundwater?

Is groundwater contaminated indirectly by inadequately treated wastes discharged to surface water?

If land application of wastewater is chosen as a best management practice, will groundwater be protected?

Groundwater is a valuable resource that can be polluted both by small onsite systems and large central treatment systems with surface water disposal. Ineffective onsite seepage beds permit contaminants to enter the groundwater without being broken down or removed. Malfunctioning seepage beds in a large development may cause the general contamination of groundwater, but isolated malfunctioning septic systems may cause only a local problem. Septage disposal practices may also pollute groundwater.

Improperly treated wastes discharged to surface water may indirectly pollute groundwater. During local droughts or times of large groundwater withdrawals, the surface water may actually recharge the groundwater. If the surface water is polluted, the groundwater will become polluted during the recharge.

In considering cost-effective treatment methods, the advisory group should plan for the protection of groundwater. Activities appropriate to this planning include:

- **Discussion of existing or past local groundwater problems caused by liquid or solid waste treatment**
- **Consideration of groundwater quality, including investigative studies, early in the planning process**
- **Consultation with persons knowledgeable of groundwater, such as consultants or governmental agencies as the United States Geological Survey**
- **Establishment of groundwater monitoring facilities and programs.**

Main Points

Groundwater is the largest source of freshwater available to humans; 95 percent of the world's supply is in the ground, but it is not all available for use.

Groundwater is water that fills the cracks and pores in rocks and soils. It is not an underground lake or river. The movement of water underground depends upon the pressure gradient of the aquifer and the composition and thickness of rock and soil layers.

Nearly half of the United States population depend upon groundwater as a source of drinking water. The reasons for groundwater use include availability, purity, reliability, and relatively low development costs.

Groundwater contamination has become a problem, especially within the last quarter century, due to the dumping of liquid and solid wastes into the ground. It is much more difficult to control or correct groundwater pollution, than surface water pollution.

Groundwater pollutants belong to three categories: biological organisms, inorganic chemicals, and organic chemicals. Groundwater is usually free from disease-causing microorganisms, because of the filtering action of the soil. Inorganic contaminants such as metals and minerals are persistent and difficult to remove.

Organic chemicals are primarily associated with industrial wastes. They often require complex analyses, and are difficult to remove from aquifers.

The causes of groundwater contamination are primarily man-made sources such as dumps, leaks, and spills, or situations that exacerbate natural processes. For example, excessive pumping of groundwater in coastal areas has contributed to saltwater intrusion into freshwater aquifers.

Various federal legislation deals with groundwater planning and protection. EPA's Groundwater Task Force is working to coordinate the administration of the principal federal laws. Some states such as New Jersey also have groundwater laws.

Advisory group members have a role in groundwater protection and planning. These opportunities include:

- **Giving information on water quality or waste disposal sites**
- **Monitoring plans for adequate attention to areas of local concern, such as the quality of drinking water**
- **Encouraging protection of aquifer recharge areas from solid and hazardous waste disposal**
- **Suggesting controls of groundwater withdrawal to prevent depletion or pollution of the groundwater**
- **Evaluating the groundwater management and waste disposal policies suggested for the area**
- **Developing public support for the groundwater management strategies.**

Groundwater Protection

Middlesex County, New Jersey

The Middlesex County 208 study, begun in 1976, illustrates the importance of groundwater investigations to areawide planning objectives. Middlesex County is located in northern New Jersey adjacent to the New York City metropolitan area. It contains many industries. Groundwater provides for one-half of the county's water demand. Groundwater aquifers include consolidated rock such as sandstone, and shale or unconsolidated materials such as coastal sand and gravel. The water table in some aquifers has declined due to continuous water withdrawals for industry and the public. As a result of this lowering of the water table, saltwater has entered one aquifer and is moving towards wells. Potential sources of groundwater pollution beside the saltwater intrusion include 4,500 onsite waste disposal systems, 17 liquid waste lagoons, 47 landfills, and a large number of spills and leaks from industries handling hazardous chemical and petroleum products.

Groundwater Study

A groundwater study using 600 wells included data on geology, aquifers, water levels, and pumpage. A series of 20 maps and cross-sectional drawings were prepared from this study. Aerial photographs were used to inventory waste disposal activities, and then to pinpoint potential sources of groundwater contamination. This step was followed by field reconnaissance. Maps were constructed showing septic tank density, waste disposal lagoons, landfills and dumps, storage of hazardous products, and reported oil or chemical spills. The impact of waste disposal activities on groundwater and surface water was determined, and a series of water quality management options was provided.

Groundwater Recharge Management

Water withdrawal procedures

Reallocation of well pumpage

Limitations on pumping in recharge areas

Control of industry in recharge areas

Aquisition of recharge areas

Zoning to promote lower density in recharge areas

Installation of detention basins to enhance recharge

Control of toxic substance handling

Landfill and mining regulations

Preservation of prime agricultural land

General drainage improvement

Water Supply and Consumption Management

Conservation of existing water supplies

Coordination of water quality and water supply planning

Coordination of water supply and economic development planning

Reduction of municipal and industrial consumption

Protection Strategies

In 1979 and 1980, federal 208 grants were awarded for the continuing planning process. The focus of these grants was to protect the groundwater using two management approaches:

- Groundwater recharge management
- Water supply and consumption management.

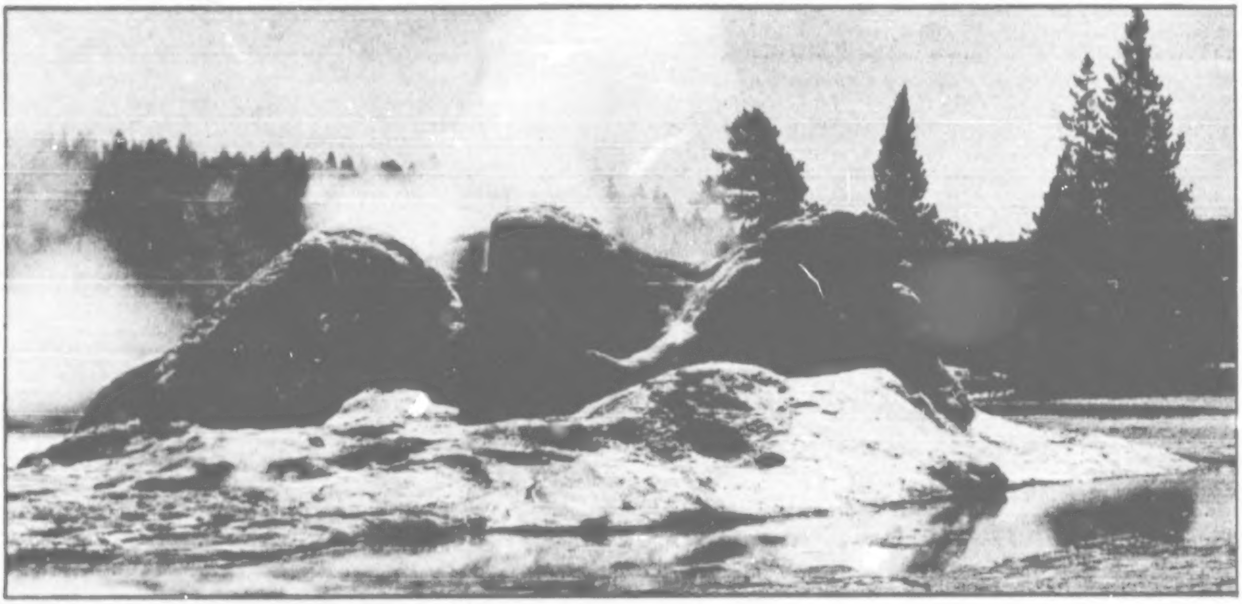
The approaches attempt to take care of both the demand and supply parts of the problem. Groundwater recharge management aims mainly at protecting aquifer recharge areas in order to facilitate replenishment of underground water stores with high quality water. Management of water supply and consumption attempts to conserve existing supplies and plan for resource availability.

A concern of the people participating in the water quality management planning is to protect groundwater recharge through land use controls. The planners are looking at the protection of groundwater in the southern, less developed part of the county and at the *identification and control of contamination* in the northern part of the county.

Citizen Involvement

One objective of the project is to institutionalize groundwater protection in decision making. Previously, protection was attempted on an ad hoc basis. Citizen input to 208 planning has become an ongoing program. In 1975 an initial planning grant called for a planning advisory group to be established. There were also basin advisory groups. Public and private agencies with an interest in water resources were identified and utilized. Many of the persons in these groups were volunteers. By 1979 the input had evolved into a structured citizen advisory group with specific membership categories, bylaws, and other features. The membership is made up to approximately 50 percent local and county government officials, and 25 percent each of industrial and citizen-environmental interest representatives. This advisory group, called the Lower Raritan-Middlesex County Water Resources Association, meets on a quarterly schedule.

Grotto Geyser, Yellowstone National Park.



Need More Information?

Baldwin, H. L. and McGuinness, C. L. *A Primer on Groundwater,* Washington, DC: United States Department of Interior, Geological Survey, 1963. 26 pp.

> This is an introductory booklet on groundwater. It has become a classic within the USGS. Even though it is old, it has been reprinted numerous times. Subjects such as groundwater availability and quality, wells, and groundwater management are included. It is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Groundwater: An Overview. CED-77-69. Report to Congress by the Comptroller General of United States, Washington, DC: General Accounting Office, June 21, 1977. 46 pp.

> This report is a general review of groundwater resources and problems in United States. It is available from the U. S. General Accounting Office, Distribution Office, P.O. Box 1020, Washington, DC 20133.

Groundwater Pollution Control, It Depends On You. Worthington, OH: National Water Well Association, 1976. 16 pp.

> A colorful brochure describing the various activities which threaten the quality of groundwater, this booklet gives suggestions for eliminating or keeping potential pollution to a minimum. It is available from the National Water Well Association, 500 West Welson Bridge Road, Suite 135, Worthington, OH 43085.

"Groundwater Protection," *Water Quality Management Bulletin,* Washington, DC: U.S. Environmental Protection Agency, Water Planning Division, 1980. 28 pp.

> This issue of the *Water Quality Management Bulletin* describes groundwater quality protection. It includes an overview of the problem, concepts of hydrogeology, solid and hazardous wastes, groundwater related portions of the Resource Conservation and Recovery Act, Safe Drinking Water Act, and Clean Water Act, onsite disposal related to groundwater, and summaries of several groundwater pollution sources. It is an excellent reference document for groundwater protection. It is available from U.S. Environmental Protection Agency, Water Planning Division (WH-554), Washington, DC 20460. Quantities may be limited.

The Report to Congress: Waste Disposal Practices and Their Effects on Ground Water. Report No. EPA-570/9-77-001. Washington, DC: U. S. Environmental Protection Agency, Office of Water Supply, January 1977. 512 pp.

> This report describes the results of an investigation into: (1) the disposal of waste which may endanger underground water which supplies, or can reasonably be expected to supply, any public water systems and (2) the means of control of such waste disposal. The report is comprehensive, readable, and filled with facts and figures. Numerous case histories and examples are included. Available in summary form (PB-265 364/OWP) or as a full report (PB-265 081/OWP) from The National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Waste Disposal Practices - A Threat to Health and a Nation's Water Supply. CED-78-120. Report to Congress by the Comptroller General of the United States, Washington, DC: General Accounting Office, June 16, 1978. 34 pp.

> A general review of our waste disposal practices including their impact on groundwater and health. It is available from the U.S. General Accounting Office Distribution Office, P.O. Box 1020, Washington, DC 20133.